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THE CANADIAN ASSOCIATION OF GEOGRAPHERS

THE CANADIAN GEOGRAPHER

LE GÉOGRAPHE CANADIEN

L'ASSOCIATION CANADIENNE DES GÉOGRAPHES

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Son Excellence, le Gouverneur Général du Canada, le Major-Général Georges Vanier, D.S.O., M.C., C.D., recevait, à Rideau Hall, le 18 décembre 1959, des mains de l'Honorable Paul Comtois, Ministre des Mines et des Relevés techniques, un exemplaire de *l'Atlas du Canada*. On aperçoit sur cette photo, Son Excellence félicitant le docteur N. L. Nicholson, Directeur de la Direction de la géographie pour l'élaboration de cet ouvrage, peu après que l'Honorable Comtois (au centre) en eut fait la présentation.

His Exellency, the Governor General of Canada, Major-General George P. Vanier, D.S.O., M.C., C.D., was presented with a copy of the *Atlas du Canada* by the Honorable Paul Comtois, Minister of Mines and Technical Surveys, at Government House, Ottawa on December 18th, 1959. In the above photograph His Excellency congratulates Dr. N. L. Nicholson, Director of the Geographical Branch of the Ministry, on the production of the Atlas, after Mr. Comtois (centre) had made the presentation.

THE SCENERY OF CENTRAL AND SOUTHERN ARCTIC CANADA *

J. BRIAN BIRD

President of The Association, 1958-59

RÉSUMÉ. *Il y a une quinzaine d'années la cartographie et la géographie physique des régions arctiques du Canada n'en étaient qu'à leurs débuts. L'exploration scientifique, facilitée par l'avènement de l'avion et par la participation accrue des autorités gouvernementales a produit depuis des résultats notables dans plus d'un domaine. L'étude scientifique des formes du terrain en autres, a été l'objet d'importantes recherches. Il est maintenant possible grâce à cette recherche de présenter un aperçu préliminaire de l'évolution du paysage arctique.*

Dans de vastes régions du Canada arctique l'élément dominant du paysage est constitué par de hautes surfaces plates ou légèrement ondulées. Plusieurs groupes de surfaces, indépendantes des influences structurales, peuvent être déterminées. Le plus haut niveau, la surface de Penny, profondément disséquée et partiellement recouverte par les glaces, s'étend de l'est de l'île Devon au Labrador et atteint 6,000 pieds au-dessus du niveau de la mer. A l'ouest du premier, un second groupe de surfaces a une altitude approximative de 2,000 pieds. Un troisième groupe, sis entre le détroit Parry et le nord de la baie d'Hudson, est formé en majeure partie de plateaux admirablement bien conservés. D'autres surfaces de même types ont été observées dans le secteur oriental du district de Mackenzie. Les basses-terres séparant ces surfaces ont été formées, du moins en partie, à une période ou le niveau de la mer était à plusieurs centaines de pieds plus bas que le niveau actuel. Le relèvement eustatique qui suivit eut pour effet d'ennoyer certaines dépressions, et qui ont formé la baie d'Hudson, le bassin Foxe, et les détroits séparant les îles de l'Arctique.

Bien que les hautes surfaces forment les éléments majeurs du modelé ,certaines formes de détail peuvent être attribuées aux glaciations Pléistocène et aux transgressions marines postérieures à celles-ci. Il est d'ailleurs probable que l'ensemble de l'Arctique a été glacié au cours du Pléistocène, mais la glace semble s'être retirée assez tôt de certaines îles du nord et du nord-ouest. La glaciation a pris fin assez rapidement, il y a cinq ou sept millénaires, dans le secteur central et oriental, sauf pour certaines régions plus élevées. La dernière glaciation a été suivie d'une trangression marine de 300 à 900 pieds et qui a submergé les plaines cotières. Le soulèvement était déjà en cours alors que la glace était en pleine fonte, et à certains endroits le niveau des eaux était à plus de 100 pieds inférieurs à celui du niveau actuel. Lors de ce soulèvement des lignes de plages et des dépôts marins sont apparus et sont devenus depuis d'importants éléments du paysage. Les modifications ultérieures du paysage furent réduites et se limitèrent à certaines actions périglaciaires.

Les recherches de géomorphologie des régions arctiques ont, depuis 1945, connu un essort important mais comme pour d'autres domaines des sciences de la terre, son développement a été sérieusement gêné par la rareté de chercheurs compétents. Il est donc impérieux, pour les autorités concernées, désireuses d'attirer vers l'Arctique des scientifiques de valeur, de seconder les efforts des chercheurs et des étudiants de nos universités par des crédits plus considérables aux fins de recherches dans ces régions.

The Presidents of the Canadian Association of Geographers have spoken on a variety of topics in their Presidential Addresses. I have chosen the study of an area which is continually in the news today. The disappearance of the western frontier in Canada early in the Twentieth Century has been followed by recognition of a northern frontier. The North, at first dismissed by most as a barren wasteland, has gradually come to the forefront until in the last few years active steps have been taken to tame it and bring it into the realm.

The North will always have a hostile environment and for economic development to be successful it must not be allowed to proceed fortuitously. A thorough inventory of the resources should be made followed by planned growth of facilities that favour the economic life of the whole region.

Foremost in the "new" exploration of the North have been geographers — initially interested in the physical environment but increasingly involved in the economic and human problems.

My own interests, helped and stimulated by the Geographical Branch, have led me into an examination of the physical landscape of the North, its geomorphic evol-

* Presidential address delivered at the Ninth Annual Meeting of the Canadian Association of Geographers, Saskatoon, Saskatchewan, 1959 : This review of the state of geomorphology in arctic Canada is based on the research of numerous individuals. For an analysis of the most important works published since 1945, see BIRD, J. Brian : Recent contributions to the physiography of northern Canada; *Zeitschrift für Geomorphologie*, 3, 1959, p. 151-174.

ution and the application of my conclusions to landscape development in the south.

I have chosen as my subject the scenery of arctic Canada because there have been exciting and significant advances in the interpretation of this vast area in the last few years, discoveries that have been made largely by members of The Canadian Association of Geographers. We have now reached a stage when it is possible to present a generalized picture of the scenery of the North that is rather different from, and a good deal more accurate than the earlier accounts. The topic is so vast that I shall limit my comments to the most significant discoveries and to point out some of the major problems that we can now define.

This is the first time that a president has addressed you on a geomorphological topic and it is surprising that no one has done so before. Geomorphology in Canada is part of geography. I do not have to remind you that the two honorary presidents of our society, Griffith Taylor and Raoul Blanchard, have both made significant contributions in the field of geomorphology. The growth of geomorphology in relation to geography in Canada is in striking contrast to the position in the United States where although geomorphology is a well-founded discipline it is rarely considered to be in the field of geography. The field has been lost by American geographers partly to geology and partly by the growth of an autonomous subject "geomorphology". Fortunately there seems little chance that this will happen in Canada. Here the geographer is continually reminded of the strong influence of physical environment on the growth of the country particularly when he leaves the relatively small, heavily industrialized areas of the south. In the early stages of any frontier settlement environment is a fundamental factor and the land as part of the environment plays a significant role. An examination of the recent development of geomorphology in parts of Africa, Australia, and the USSR shows that geomorphology thrives in a practical sense and also theoretically in some of the underpopulated, underdeveloped but resource-rich areas of the world. Not only are there valid practical reasons why geomorphology and geography should be linked in Canada but there are also good academic reasons, namely the strong and continuous contact with French and British schools of geography where geomorphology is important.

The physical geographer can make significant contributions in all areas of Canada. In the south there is a desperate need for sound physiographic description as a basis for the human and regional studies that we anticipate in the near future. In the only serious regional treatments so far published, the volumes by Blanchard on Quebec, the author prepared his own physiographic description. Elsewhere the only suitable physiographic contribution covering a major region is that of Putnam and Chapman, in southern Ontario. If ever an example was required of the importance of regional physiographic studies in the early stages of geographical research I suggest you search for any post-1950 publication in geography, or any related topic, on southern Ontario in which the author has not drawn on Putman and Chapman's work. The demand from within Canadian geography as well as from outside should lead, therefore, to an increase in the study of physical geography — together with the other branches of geography — within the university system of teaching and research, and within government departments.

The main contribution that the physical geographer has made, so far, has not been in the south, but in the scientific exploration of the Arctic and Subarctic. Arctic Canada covers an area of nearly 1 million square miles. If the forest-tundra transition zone immediately to the south is included, the area is about 1½ million square miles, or about three-quarters of the area of Europe west of Russia. Although in the last 15 years studies of northern Canada have proceeded at a remarkable pace, the area is so immense that despite a number of local regional landscape studies, there is no comprehensive account of either a large area (of the order of the eastern Arctic) or the geomorphic processes that are moulding it. Sufficient material has been obtained for an attempt at the overall

picture although it will inevitably require considerable modification. The area known best to me is the continental mainland (excluding a narrow strip in the northwest) and the arctic islands as far north as Parry Channel. In the discussion that follows I shall restrict myself to this area.

GEOLOGICAL BACKGROUND

Limited comment on the general geology of arctic Canada is essential because of the close relationship between landforms, terrain, and geology. Since 1945 considerable progress has been made in northern geology, almost entirely by the Geological Survey of Canada. Their plan to cover almost all of the North with regional mapping on a reconnaissance scale is now well under way aided by new travel techniques using, first helicopters, and more recently on the islands light, fixed-wing aircraft.

Nearly the whole area under discussion is in the Canadian Shield or is underlain by relatively thin, flat-lying, sedimentary Palaeozoic rocks that mantle the Precambrian basement. To the north and northwest and fringing the area is the geologically unstable Innuitian region that was tectonically active into the Tertiary.

The geomorphologist is primarily interested in three aspects of the geology — the lithology, particularly the response of different rocks to geomorphic processes; the distribution of the rocks both in the past and the present; and the recent sedimentary and structural record during the formation of modern landforms.

The fundamental division of Precambrian strata is into Archaean and Proterozoic. The earlier group is dominated by granitic gneisses which develop a remarkably constant type of scenery varying only with the depth of incision of the streams. The later group includes limestones and dolomites, sandstones, volcanic rocks, and in some areas diabase sills. Where these sediments are horizontal and uniform, broad plains have developed as in central Keewatin; elsewhere, where they are tilted, spectacular cuesta scenery is found, such as south of Coronation Gulf or parts of Somerset Island.

The Palaeozoic sediments, mainly limestones, are preserved in basins between arches in the basement rocks. Plateaux and plains, often separated by scarps, develop on the limestone and the terrain is generally very different from the Precambrian areas. These basins are found in Hudson Bay, Foxe Basin, Gulf of Boothia-Lancaster Sound, Victoria Strait, in western and again in northwestern Victoria Island. It is obvious that general major physiographic features of northern Canada ultimately originated in these structures. It is equally clear that the Palaeozoic sediments were at one time more extensive and that the modern drainage patterns may have to be interpreted in terms of superposition from a Palaeozoic cover. The last widespread period of sedimentation in the southern and central Arctic was in mid-Palaeozoic times and subsequent sedimentation has been slight. The only sediments of Mesozoic age that have been recognized are probably Cretaceous; they are present in the Labrador Trough (although there is still some doubt of their age) and they have been found immediately south of the area in northern Ontario, as well as around the margins of the Canadian Shield. Some of these sediments are of continental origin and the extent of the Cretaceous transgression remains unsolved although potentially of importance to the geomorphologist.

Tertiary sediments have also a limited distribution. Small pockets of rocks of this age are preserved on Bylot and Baffin islands and are more extensive in the northwest from Banks Islands to Meighen Island. There, on the outer edge of the Queen Elizabeth Islands, they form the Beaufort series, unconsolidated sands and gravels that reach several hundred feet in thickness.

The absence of post-Palaeozoic sediments in most parts of the area makes it imperative that the evolution of the scenery is determined primarily from the landforms.

THE UPLAND SURFACES

Throughout arctic Canada the evolution of the scenery and terrain chronologically falls into three periods. The preglacial epochs, primarily the Cenozoic, during

which the majority of present large landforms developed; secondly, the glacial period when many of the smaller, depositional landforms were produced and the surface deposits which generally control the local terrain were significantly modified and thirdly, the postglacial period when the lowlands experienced marine transgression and geomorphic processes have modified, albeit very slightly, the earlier landforms.

Throughout this time sea level has apparently fluctuated widely so that many landforms that evolved subaerially are now submerged. Climate has also varied greatly. Certain schools of geomorphology, notably in France, emphasize such climatic fluctuations, but I find little evidence that different climates, other than the prevailing periglacial conditions and the glaciation itself, have played an important role in the evolution of the scenery of arctic Canada.

In the absence of sediments, the chronology and pattern of the development of the landscapes of northern Canada during the Cenozoic, the first of the periods, will be determined from studies of the upland surfaces and drainage patterns. This history is not traced here partly because discussion would be premature and partly because it is peripheral to the main subject. The fact that there are upland surfaces, that in many areas they are conspicuous features of the landscape and that they control the type of terrain and movement across them, is of the greatest importance.

The term upland surface is used for extensive flat or gently rolling surfaces that transect rocks of different lithology and that can be shown to be a part of a former erosion cycle. The Appalachians are generally considered as the classic area in which upland surfaces are preserved. Yet, in the eastern and central Arctic there are upland surfaces far more extensive and with a greater degree of preservation than in the Appalachian-Acadian region. To illustrate this I should like to describe briefly what has been called the Barrow Surface. It is found on crystalline Precambrian rocks on Boothia Peninsula, Prince of Wales Island, and Somerset Island at a height of 1,050 - 1,250 feet. On Somerset Island it extends from granitic rocks across Proterozoic and Palaeozoic sediments of very different resistance to erosion, without any change in altitude. It is found at roughly the same height and with the same rolling nature, north of Barrow Strait on western Devon Island and southeastern Cornwallis Island. It also dominates Brodeur and part of Borden peninsulas in northwest Baffin Island. It covers at least 50,000 square miles throughout which it is found on many types of rock and is apparently horizontal.

Other uplands, although perhaps not as well preserved as the Barrow Surface, are none the less extensive. In the eastern Arctic provisionally they may be divided by altitude into three groups.

The highest surface has an elevation of 5,500 to 6,000 feet. It is preserved in the east of Devon Island, in Bylot Island and intermittently along the east side of Baffin Island notably in the Penny Highlands north of Cumberland Sound after which it has been named. The same surface is probably found in the Torngat "mountains" and elsewhere in Labrador. This upland does in fact form the widely recognized highland rim of northeastern North America. Although erosional flats survive at this altitude dissection has been intense and the evidence for a former widespread surface is principally in accordant summit heights. Icecaps cover a large part of this dissected surface in the north. They appear to have developed first in the valleys and, as they expanded and thickened, largely but not entirely submerged the remnants of the upland.

The second group of surfaces has a general height of about 2,000 feet. It is found on the west side of the Penny surface from central Devon Island, through Brodeur Peninsula and elsewhere on Baffin Island where it forms the backbone of the island; in the southeast it dominates Hall and "Frobisher" peninsulas. Eventually this surface may be shown to continue into central Labrador-Ungava. Unlike the Penny surface this upland is well-preserved away from the margins and has a rolling form supporting gentle domes. It is not known if this surface is horizontal. Radar

profiles and visual observation show that it rises to the east in Baffin Island. It may be tilted, but equally, and perhaps more likely, the upland may actually be a series of surfaces that are progressively higher towards the east. Even if it is tilted it is not upwarped sufficiently to become part of the Penny surface which it surrounds on the Baffin Bay — Davis Strait side. Although observations from Labrador suggest that the two levels merge, alternative interpretations are possible.

The significance of the 2,000-foot surface in the landscape is two-fold. It forms a suitable foundation for plateau icecaps, the largest of which is the Barnes in central Baffin Island. If the present climate were to deteriorate sufficiently for an ice sheet comparable to the Pleistocene icecaps to form, the ice would not accumulate at first on the highland rim but on these uplands. Secondly, deep dissection, in part by ice and in part by rivers when sea level was lower than at present, has produced magnificent fiords around the edges of these uplands.

The age of the Penny and the 2,000-foot surfaces is unknown. Questionable deposits from northern Quebec suggest that the 2,000-foot surface may possibly be Cretaceous in age and has not been materially changed since then. Conceivably it could be much older, as on the west side of the Labrador Trough the same, or at least a similar surface is apparently being exhumed from beneath Proterozoic sediments.

The third group of surfaces is in some ways the most puzzling, possibly because it is so widespread. In this group a number of uplands are discussed together, not because there is any proof that they are of the same age, but because they have roughly the same height.

The Barrow surface is an important component of the third group. A similar erosion surface at about the same height may be found south of Fury and Hecla Strait in Melville Peninsula where it is preserved on granitic rocks, around Wager Bay, on Southampton Island on both Precambrian and Palaeozoic rocks, possibly in Foxe Peninsula where there is a conspicuous accordance of summits, and on the south side of Hudson Strait. It is probable that some evidence of the Barrow surface will be found south of Boothia Peninsula but it is remarkable if it is so widely preserved at a constant height. The age is again unknown except that it must be younger than mid-Palaeozoic and it was formed after the final sinking of the Palaeozoic basins.

Upland surfaces are also found in eastern Mackenzie District. They are separated from the uplands already discussed by the Keewatin plains and, therefore, correlation is dubious. The highest surface at about 1,400 feet is found around Contwoyto Lake. Monadnocks survive on it, including the Peacock and Willingham hills. Between the Contwoyto Upland and Coronation Gulf and Dease Strait other horizontal uplands are found at lower elevations.

Erosion surfaces lower than about 1,000 feet are restricted to the weaker rocks. They are commonest on limestone where erosional remnants form low plateaux. Some of the limestone plateaux are structurally controlled and are not strictly upland surfaces but field surveys show that at least in western Baffin Island and Southampton Island, the plateaux are independent of structure.

On the higher upland surfaces outcrops of bedrock are rather rare and they are normally covered with drift. The origin of the drift is one of the interesting problems of northern geomorphology. Some of the drift is clearly of glacial origin, but there is a good deal of evidence that much of it is a preglacial (or interglacial) deposit that formed *in situ* and has been modified very little by ice. The uplands are open, wind swept, and invariably barren. As a result they never attracted Eskimos but in some places it has been found feasible to build and operate airfields and other military installations.

The edges of the uplands show great contrast with the undissected interior. Rivers are ungraded and are unsuitable for boats larger than canoes. Deep valleys and steep cliffs often make it impossible to get onto the upland by land routes. Indeed, one of the main barriers to the exploration of the interior in large areas of

northern Canada before the use of aircraft was the difficulty of moving out of the coastal valleys onto the uplands.

Deep dissection is most spectacular in the eastern Arctic close to the highest uplands. In northern Labrador, Baffin, Bylot, and Devon islands deep coastal valleys have been converted by glaciers into fiords. In these areas it is frequently impossible to find sites near sea level for even small settlements; in at least one case it has been necessary to place an airfield on the 2,000-foot upland surface although it is in sight of the sea. Although these problems of accessibility will be serious in the development of the eastern Arctic they lead to magnificent scenery. It is amongst the finest arctic scenery in the world and may eventually become the basis of a summer tourist trade in the same way that north Norway and Svalbard attract visitors. Fiords with walls 2,000 and 3,000 feet high extend many miles into the mountain masses which are covered with ice and snow on their higher parts. At the heads of the fiords there are green sheltered valleys and yet beyond them you can see the glaciers.

Erosion surfaces of very different age and origin are found in many coastal areas. They have normally developed on Precambrian granites, producing a distinctive landscape that is unusually flat, rocky, very barren, and covered with lakes. These surfaces are so widespread that this scenery is often considered typical of the Arctic. They generally dip beneath the sea with a slope of less than 18 inches a mile and the coastal waters are remarkably shallow and are filled with small islands and reefs. The west coast of Ungava Bay, part of southwest Baffin Island (both areas of mineral deposits that may be exploited in the near future and are to some extent handicapped by these characteristics), and the west side of Hudson Bay are among the areas in this category. Without exception these lowlands appear to be recently exhumed surfaces. They are ancient coastal plains (or in some cases marine platforms) that were preserved beneath sediments, only to be uncovered again in late Tertiary and Quaternary times. Many were buried beneath Palaeozoic limestone from which they are being actively exhumed today. Some, notably Simpson Plains, may have been preserved beneath Proterozoic sediments.

SUBMERGED LANDFORMS

One of the great advances in the earth sciences in recent years has been the recognition of the complexity of submarine morphology and an appreciation of the widespread implications not only to oceanography but to geomorphology and other sciences. There are at present not more than a few hundred soundings for the whole of the Canadian arctic seas, and many of these were obtained during military operations and are not generally available. Conclusions about the submarine morphology are consequently difficult to draw. New techniques make it possible to take rapid soundings through the ice and we should soon know more about the underwater topography.

Even without knowledge of the submarine landforms we can recognize from the coastlines of submergence that sea level has been lower than at present. Locally, glacial overdeepening may mean that submergence is apparent rather than real but when the maps and photographs are examined it is abundantly clear that in all the Arctic, coastlines of submergence are only lacking in areas of recent active sedimentation (including deposition from ice). With the additional evidence of such features as the drowned cirques of southeast Baffin Island and Labrador it must be accepted that many former land areas in the Arctic have in recent geological time been drowned by the sea.

The significance of this submergence becomes evident when charts are examined. The floor of Hudson Bay was apparently at one time a lowland drained by rivers, the valleys of which still cross the bay towards Hudson Strait. Hudson Strait by this interpretation becomes the submerged valley of a river that at one time drained an area at least 50 percent greater than that drained today by the Mississippi River. The position of Hudson Strait is probably

controlled by structural factors but it is nevertheless an erosional form.

It has been suggested that the islands in the Canadian Arctic Archipelago might be the unsubmerged higher land between drowned river valleys. It has become increasingly clear that this is so, and already the former drainage pattern can be reconstructed. The valleys are remarkably deep and if they were formed subaerially with only minor modification by ice the land relative to the sea is at least 1600 and probably more than 2000 feet lower than at one time. A third area in which submergence is indicated is in the Beaufort Sea where sea valleys, possibly former channels of the Mackenzie, have been mapped.

These discoveries give two important results of which one has a very practical application. Many channels in the northern islands are extremely shallow; if they contain icebergs, remnants of ice islands, or even very heavily pressured ice, submarines will have some difficulty in travelling submerged beneath the pack ice — if there are deep, though narrow channels between many of the islands, we may yet see merchant submarines bringing minerals products out from the area throughout the year.

The other consideration is a theoretical one; it is the problem of whether the existing submergence is a delayed result of the glaciation and that the land will eventually regain its former height, or the changes are longer term and are independent of the glacial history. Evidence suggests that the second view is probably the correct one.

The major elements in the landscape were probably already in existence at the close of Tertiary times. During the Pleistocene glaciations these landforms were modified erosionally to a limited extent and the surface deposits, on which so much of the detail of the landscape depends, were radically changed.

PLEISTOCENE GLACIATION

The solution of the glacial history of the Arctic requires the combined efforts of scientists from many different disciplines. The oceanographer, the glaciologist and the climatologist, the botanist and zoologist, and the archaeologist as well as the geographer and glacial geologist are interested in this period of the earth's history, for the present is not only the key to the past, but the past in many cases may also be the key to the present. Eventually we may have to reconstruct coherent physical geographies for the past in the same way as in historical geography we reconstruct past human geographies.

Comprehensive analyses of the glacial history of northern Canada have been restricted to studies of glacial landforms as they appear in air photographs and a number of different studies of this type have now been made. In an unexplored area they provide a preliminary, quick method of outlining some of the problems. But it is clear that the method has limitations and that conventional field methods plus air photographs are essential to the correct solution.

It has been difficult to find conclusive evidence of multiple glaciation in northern Canada although there is no reason to think otherwise. This discussion will be limited to the final glaciation and particularly to the final phases when the terrain and detail of the landforms as we recognize them today were being produced.

It has been widely held that the last glaciation in east North America began along the highland rim of the continent. It now appears that there are two rather important modifications to this view. Before the main glaciation there was a small and independent icecap centred on the central, southern arctic islands. It is not known if there were other icecaps at this time over the Queen Elizabeth Islands. It is perhaps futile to speculate on the significance of this icecap and whether it was nourished from an open polar sea; not as has been suggested, open at the height of the glaciation but during the final stages of the interglacial. Whatever its cause, this ice vanished before the main glaciation reached its climax and was partly replaced by ice from the mainland.

The other modification is that the origin of the Laurentide ice sheet is now thought to have been on the broad upland surfaces of central Baffin Island rather than in the disconnected highlands of the east of the island. A major icecap certainly did not accumulate until the glaciation limit had sunk below the 2,000-foot uplands. Shortly afterwards ice began to form on the lake plateau of Labrador-Quebec. In the early stages the ice must have spread rapidly by the amalgamation of small icecaps.

The main expansion of the ice was to the west and south. On the north side arid conditions prevailed and the glacierized area of the southern islands actually decreased. It has been argued on botanical and geomorphological grounds that nunataks survived along the eastern highland edge of the Arctic during the glaciation. This view is difficult to accept and probably all northern areas (with the exception of some of the islands), were buried by ice although some areas may have been uncovered at an early period.

Long before the final phases of the deglaciation and possibly coinciding with an interstadial or warmer interval in the south, the Laurentide ice retreated from its furthest northern and northwestern limits. At the same time the higher coastal areas may have been uncovered in the east. The subsequent retreat is complex and it is not possible to describe it rationally at present. At many points the disappearance of the ice coincides with the flooding of areas by the sea and the ice sheets calved directly into the sea or into large lakes. Consistent radiocarbon dates when this occured are not available but it may have been about 8,000 B.P. north and west of Hudson Bay and rather later on the east side.

The last ice survived in two very different physiographic areas — on the broader eastern and central uplands of northern Quebec, northwest of Hudson Bay, and in central Baffin Island where the Barnes Icecap may be a surviving remnant and in some of the deeper basins notably Cumberland Sound, Frobisher Bay and conceivably Ungava Bay.

In the highlands of the eastern Arctic the glacial landforms are those associated with mountain glaciation — overdeepened valleys, fiords, cirques, horn mountains, and other features that give the spectacular scenery already mentioned. Many of these landforms are being actively developed today and complete glacierization might halt the process. The optimum climate for their evolution is probably the same temperature but rather snowier than at present. In this view the glacial mountain landforms are a product of interglacial rather than glacial times. These erosional forms are restricted to the eastern Arctic. The most westerly cirques are found on the east coast of Southampton Island.

The lowlands and plateaux north of the perimeter of the Laurentide ice show little morphological evidence of glaciation and it is in fact difficult to show if these areas were glaciated.

In the lowlands formerly covered by Laurentide ice, glacial erosion was limited; although there has recently been some opposition to this view the evidence is strong that erosion was remarkably slight. There was local abrasion of rock knobs but the joint-controlled lake basins in the granite areas that have been cited as evidence for erosion, may be explained alternatively in terms of preglacial or interglacial weathering with the function of the ice merely to remove the weathered products. The glaciation affected the scenery mainly by mixing and redepositing existing weathered products.

Lowland drift resulting from the glaciation may be placed in three categories according to its influences on the scenery. The first is till, without special landforms. In some areas it is so thin that it fails to cover the rock and may be just a sprinkling of boulders, any finer material having been washed down into the hollows. At the other extreme, as in central Keewatin, the till may be over 100 feet thick. When it is 20-30 feet thick, it usually completely buries the bedrock. The character of the till varies widely depending primarily on the parent rock. In the eastern Arctic it is generally bouldery; in Keewatin sand is the dominant characteristic whilst in the

west and north it has a high clay and silt content. No special landforms develop on the till in this category and the surface is normally rolling, featureless. Till, comprising the second category, has been moulded into landforms. The most widely distributed are the drumlinoids that cover broad areas of the lowlands of Keewatin, southern Victoria Island, the plateaux of eastern Mackenzie, and parts of northern Labrador-Quebec. These elongated, drumlinized, till ridges are rarely conspicuous features on the ground but they play an important role in local drainage. There are many other drift landforms produced by ice including ripple till with sinuous ridges oriented roughly at right angles to the ice motion, dead-ice terrain which often includes sorted drift, and moraines. Terminal moraines (of continental ice) are rare in the Arctic; examples are found on Melville Peninsula, in northwest Baffin Island, south of the Simpson Plain and on Prince of Wales Island. Rather more widely distributed are the small landforms variously referred to as annual or washboard moraines.

Finally in the third category are the drift landforms developed by fluvioglacial processes, of which the most conspicuous are eskers. These are the easiest of all landforms to map from air photographs and the extensive esker patterns are well-known. In some areas, as for example around Contwoyto Lake, on Victoria Island, and on the north side of the lower Back River, eskers are the only prominent landforms over hundreds of square miles. Less striking although locally as important are the kame deposits, valley trains, and areas of outwash.

MARINE AND LACUSTRINE SUBMERGENCE

Modification of the arctic landscape has continued in the relatively short period since the disappearance of the ice sheets. The geomorphic processes associated with periglacial climates have acted in this period and are discussed below. In the lowlands the effect of glacial marine transgression has been far more spectacular. The importance of the transgression has been appreciated for more than a half century and the upper limit of the sea has been used occasionally as a major physiographic boundary.

The underlying causes behind the marine transgression have been recognized for many years and the techniques by which the limit of the transgression is determined, have been widely discussed. In practice it is not always easy to determine the limits of the postglacial sea and there are some paradoxical results that have not been resolved. For example emergence of more than 2,000 feet has been measured on Ellesmere Island and about 1,000 feet over wide areas on the central arctic islands while in some adjacent areas emergence is as little as 300 feet. Despite these inconsistencies it is clear that the area covered by the sea, and the elevation of the land since the maximum submergence are greater in the Canadian North than in other parts of the world. A great number of observations are available of the extreme height reached by the sea. Some of the inconsistencies between local measurements are presumably due to faulty observations but even so there are enough to suggest that rapid changes in elevation of the highest strandlines over short distances are real.

There is a basic difference between emergence along the eastern seaboard and other parts of arctic Canada. On the Atlantic, Baffin Bay, and Davis Strait coasts the highest marine strandlines are generally between 200 and 350 feet above present sea level but in some areas they do not exceed 10 feet. There are several causes for limited emergence. The total depression of the land in the east was less than farther west; the continental ice retreated earlier from the east when world sea level was still low and in some of the fiords subsequent readvances of local ice destroyed earlier strandlines. A further peculiarity of the east is that the emergence appears to have been intermittent rather than continuous.

In the centre and west the story is very different. Emergence of the land over broad areas has been in excess of 700 feet with a maximum of at least 900 feet

on the east side of Hudson Bay. Within the high-emergence areas there are local pockets of smaller uplift; for example, the marine limit is consistently less than 400 feet around Wager Bay, in contrast to the altitudes of 525 to 625 feet that are found from Fury and Hecla Strait south to Southampton Island, and around Chesterfield Inlet. In the western Arctic where the determinations are for a variety of reasons more difficult to make, the upper limit generally seems to be at 500 - 600 feet.

It is now possible to give a fairly accurate date to the emergence in the central Arctic. If we assume that the marine transgression was at a maximum as the ice vanished, then over wide areas there has been emergence of the order of 600 - 700 feet in the last 8,000 years. Isolated radiocarbon dates show that emergence was at first extremely rapid. It was certainly 25 feet a century and may have reached 50 feet. Radiocarbon dating of the emergence in many areas is still required to enable numerous archaeological and botanical, as well as geomorphological problems to be solved.

It has often been asked if emergence is continuing. Despite the controversy about the interpretation of certain sites, notably Sloops Cove, Churchill, gravimetric, hydrographic, and geomorphological evidence is that the land is still rising in many areas but that it is unlikely to be greater than 3 feet a century: in contrast the Mackenzie delta may be sinking.

The effect of the transgression on the scenery was essentially twofold. In most areas wave action resorted the loose surface material left by the ice, washing the fines to deeper water and leaving strandlines that are today elevated far above the present sea. The strandlines are most conspicuous in limestone areas but are also prominent on sandstone and basalts; they are so extensive in some limestone lowlands that the whole character of the scenery is dominated by them. When the clay and silt fraction is removed from limestone till by wave action, areas which are natural building and airfield sites are left, in which permafrost problems are at a minimum. In spite of the importance of waves in forming strandlines, erosion in the more resistant rocks has been negligible. Although bluffs were formed in unconsolidated material these have been destroyed by mass wasting.

Widespread deposition of marine silts and clays accompanied the transgression. They are of great significance in the western Arctic but are only locally important east of the Somerset Island - Boothia axis, a distribution that leads to fundamental differences in landscape between the eastern and western arctic lowlands. The submergence also resulted in the formation of river terraces and high level terraces that are often spectacular.

Less important has been the effect of proglacial lakes. The largest lakes, comparable in size to the large proglacial lakes in southern Canada, were formed in Keewatin and eastern Mackenzie by ice dams to the east. Smaller but significant lakes also existed in northern Labrador-Quebec. These lakes often formed conspicuous strandlines but deposition in them seems to have been slight.

ADDITIONAL CHANGES IN THE POSTGLACIAL LANDSCAPE

By the time the ice sheets had disappeared and the sea retreated from the arctic lowlands, the scenery was very similar to that seen at present. Partial colonization by vegetation has taken place and today the presence or absence of vegetation is apparently the controlling factor in the severity of the various geomorphic processes.

Since the disappearance of the ice and sea, a period of less than 8,000 years in most areas and less than 3,000 years in some of the coastal sectors, the geomorphic processes have had little time in which to be effective. In the areas of granitic and other resistant rocks modification of the bedrock surface has been negligible. Frost shattering has been restricted to exposed ridges and to some sides of the overdeepened valleys in the highlands. In the regions of weaker rocks the processes have been more active. Many of the sedimentary rocks show evidence of recent frost shattering, although this is rarely extreme. It is

Burnside River entering the lower gorge near the mouth. The river formerly flowed through a valley on the right, now blocked by till and marine silts.

Hiukitak River entrenched into an upland surface, east of Gordon Bay, Bathurst Inlet.

The eroded edge of the Barrow upland, Somerset Island. Deltas, partly elevated, from tributary valleys, almost fill Batty Bay.

An outlet glacier from an icecap on Hall peninsula, Baffin Island.

An elevated sand delta crossed by fissures, Nettilling Fiord.

One of the numerous large eskers that lie on the Contwoyto upland surface in eastern Mackenzie District.

Coastal lowlands developed on trap rocks, Melville Sound.

Nivation hollows developing beneath snow banks, Prince Leopold Island.

Dry valley in limestone near Amadjuak Lake.

Hills west of Nettilling Fiord, Baffin Island, formed by the dissection of an upland surface.

The western edge of the Putnam Highland. The margins of this limestone plateau were submerged by the post glacial marine transgression. The top escaped submergence.

Assymetrical ridges developed on steeply dipping quartzites west of Bathurst Inlet. The area has been exhumed from beneath diabase flows, remnants of which appear to cover pieces.

best developed in limestone and sandstone when there is neither overburden nor vegetation cover. Even under these conditions meteorological and soil temperature observations suggest that postglacial shattering may not be as great as previously supposed. Field observations support this opinion; on Devon Island where there are magnificent sandstone felsenmeere, the shattered rock predates glaciation. It is visibly appearing from beneath the ice as the glaciers retreat today. Similarly there has been a tendency to overestimate the amount of chemical weathering on limestone in postglacial times. Although theory suggests that the power of groundwater to attack limestone reaches a maximum when water is cold, its application to northern Canada is not confirmed by field observations.

In surficial deposits there have been significant postglacial changes. Mass movement in the active layer has led to the redistribution of material and a lowering and smoothing of slopes. Solifluction is clearly important in deep, fine-grained, glacial drift and marine sediments such as are found on many of the central arctic islands and in the western Arctic. Localized movements in soils lead to patterned ground. In spite of numerous studies the origin of patterned ground remains obscure.

Other postglacial geomorphic processes will only be mentioned briefly. There has inevitably been aggradation in some areas from streams, elsewhere there has been limited wind action, but in terms of postglacial changes in landscape these processes are negligible. Periglacial processes unquestionably form a definite branch of study in geomorphology but they have yet to modify the postglacial scenery of northern Canada.

CONCLUSION

This review summarizes our present knowledge of the evolution of northern scenery. Some of the most urgent problems have been mentioned. Primarily we require detailed studies of all phases of landscape evolution in as many areas as possible with particular emphasis on the periglacial geomorphic processes. The application of the theoretical work to practical problems connected with economic development should follow; particularly in terrain studies and the physical and engineering properties of soils where permafrost is present. These studies will only be possible if the scientist receives considerable support. No opportunity should be lost to emphasize that worthwhile results will only be attained if the research can be planned and developed over relatively long periods of time preferably from small, semi-permanent research stations. Fortunately the financial difficulties of undertaking arctic research are decreasing. Inevitably funds for research are in one way or another being largely provided through the federal government. There are certain dangers in this and at least a small proportion of the theoretical research should be sponsored by non-government sources. In this way Canadian companies, with very small outlay, can make an important contribution to the country's future.

Another and more serious feature of the northern research programme is the lack of interested scientists. Too few university students, above all, too few really able students, are attracted by northern studies. To obtain and train such people not only in geography but also in other relevant disciplines is the really crucial problem. One answer undoubtedly would be the creation of special northern scholarships for graduate students and for undergraduates in their final years. Such a programme would repay many times its cost within a short time.

SOME ASPECTS OF INDUSTRIAL LOCATION IN SOUTHERN ONTARIO *

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ABSTRACT. *In recent years the distribution of manufacturing in southern Ontario has changed very little. Although a few areas, in particular Metropolitan Toronto, have benefited greatly from post-war industrial expansion, the pattern developed in the past continues to prevail.*

Investigation reveals that of the various economic forces affecting the location of manufacturing in southern Ontario, those of market accessibility and labour costs are the most important. The former can be defined best by computing values of market potential for selected communities, using county wholesale sales and actual trucking costs. To determine regional variations in labour costs, various categories of employment were identified, and hourly wages were secured for over fifty cities and towns.

When labour costs are related to market potential, one concludes that southern Ontario excluding Metropolitan Toronto has a remarkably homogeneous environment for manufacturing and that most industry is "footloose" within a wide belt.

RÉSUMÉ. *Au cours des dernières années, la répartition des industries manufacturières du sud de l'Ontario n'a que très peu varié. Quoique quelques régions, comme celle de Toronto, aient largement bénéficié de l'expansion industrielle des années d'après-guerre, le mode de développement qui a caractérisé le passé semble vouloir se maintenir.*

Parmi les forces économiques qui ont joué le plus dans la localisation des industries du sud de l'Ontario, l'accessibilité des marchés et le coût de la main-d'oeuvre apparaissent comme les plus importantes. En ce qui concerne l'accessibilité des marchés celle-ci est déterminée par l'estimation du potentiel commercial de villes choisies, et ce, en se basant sur le commerce de gros pour chacun des comtés et sur les frais de transport par camion. Une enquête, auprès de plus d'une cinquantaine de villes et villages, a apporté des données sur les variations régionales dans le coût de la main-d'oeuvre, sur la détermination des diverses catégories d'emplois de même que des précisions sur les salaires horaires.

Si l'on considère le coût de la main-d'oeuvre en fonction du potentiel des marchés, on peut inférer que l'industrie manufacturière du sud de l'Ontario, à l'exclusion de Toronto et de ses environs, présente des conditions remarquablement homogènes et favorables aux industries situées à l'intérieur de cette grande ceinture manufacturière.

There has been considerable expansion of manufacturing industries in southern Ontario since World War II, made up in part by existing industries which have enlarged their facilities and by new industries, mainly branches of American or European firms. Not all districts in southern Ontario have shared equally in the growth, and it is towards an understanding of the regional variations in industrial expansion that this paper is directed.

LOCATION OF INDUSTRY

Figure 1 shows the distribution of manufacturing in southern Ontario based on the number of wage earners in manufacturing in 1955.[1] Manufacturing is heavily concentrated in southwestern Ontario, in particular in the area between Toronto and London, including the Niagara Peninsula, where at least 75 percent of the manufacturing production of southern Ontario and one-third that of all Canada is found. The towns and cities east of Toronto account for less than 12 percent of the industrial production in southern Ontario, but a few outliers, especially Windsor, Sarnia and Chatham, stand out in extreme southwestern Ontario. Settlements on and near Georgian Bay, as far east as Barrie and Orillia, contribute less than three percent to the total manufacturing production of southern Ontario.

POST-WAR CHANGES IN LOCATION

It is difficult to measure accurately changes in the distribution pattern of manufacturing.[2] Statistical data are available, but each system of enumeration has

* Presented at the Ninth Annual Meeting of the Canadian Association of Geographers, Saskatoon, 1959, and published with the permission of the Director, Geographical Branch, Department of Mines and Technical Surveys.

certain limitations. The Dominion Bureau of Statistics publishes annually in its Census of Manufacturing, the number of manufacturing establishments in towns, cities, counties and census divisions in Canada. Any differences in number from year to year result from either the establishment of new companies, or the bankruptcy of existing firms, or both. However, the census does not provide information about the size of companies and the number of new firms, or their origin. Nevertheless, it is one index of change.

Somewhat more satisfactory is the material provided on changes in manufacturing employment, which shows actual growth or decline. However, changes resulting from expansion of existing industries can not be distinguished from increases due to the establishment of new companies.

For the last ten years, the Trade and Industry Branch of the Department of Planning and Development of the Province of Ontario has compiled an annual survey on the establishment of new industries in the Province, the data having been gathered from newspapers, government reports, industrial commissioners and other sources. Yet in spite of a thorough coverage, the survey does not reveal all industrial growth.

Table I is a summary of the three methods of enumeration by economic regions. All three emphasize the very striking growth in the metropolitan region. (See Figure 2)

The Niagara and Southwestern Regions show moderate growth, but eastern Ontario displays only a small increase, and the remaining regions very little. It is evident that the expansion has been quite uneven, taking place almost entirely in the areas of greatest industrial concentration. In explaining the pattern of growth, various factors will be analysed, in particular those of market accessibility, labour costs and labour stability.

MARKET

Several attempts have been made to discuss the importance of market in the location of manufacturing.[6] Manufacturers usually evaluate the accessibility of market in terms of transport costs. Ton for ton, freight charges on most manufactured goods exceed those on materials. The average manufacturer is, therefore, more sensitive to the accessibility of his potential market than to the source of his materials, and it follows that for a large number of industries, the market is the deciding factor in the selection of a location.

The concept of market in manufacturing is indeed a very broad one, and it is obvious that no one group of statistics satisfies all requirements in its definition. What constitutes the market for some manufacturers is for others a source of supply, and for this reason it is better not to restrict its statistical definition to that of retail sales. On the other hand, nearly all manufactured goods, whether destined without further processing for the retail

TABLE I

Region	% Employment in manufacturing in 1956	Changes in no. of manufacturing establishments, 1947-1956[3]	Changes in manufacturing employment 1947-1956[4]	No. of new industries 1949-56[5]
Eastern	7.0	— 19	+ 5,410	56
Lake Ontario	4.0	— 47	+ 3,191	38
Metropolitan	43.0	+965	+66,088	362
Niagara	19.0	+186	+11,110	104
Georgian Bay	2.5	+ 10	+ 361	39
Mid-Western	10.0	+ 47	+ 1,180	75
South-Western	14.5	+199	+ 9,296	129
Total-Southern Ontario	100.0%	1,341	96,636	803

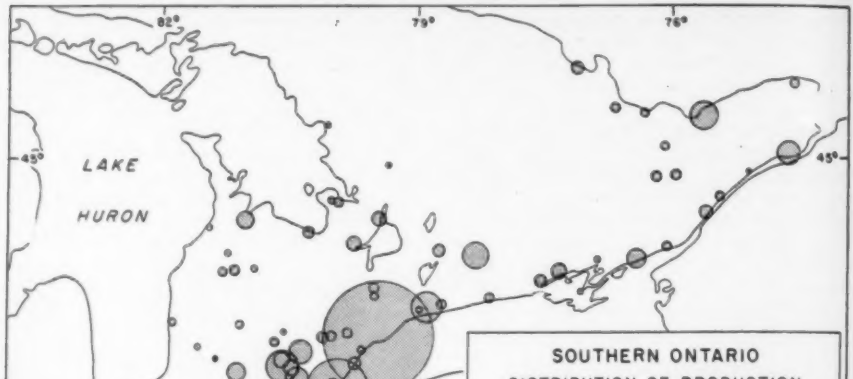


FIGURE 1

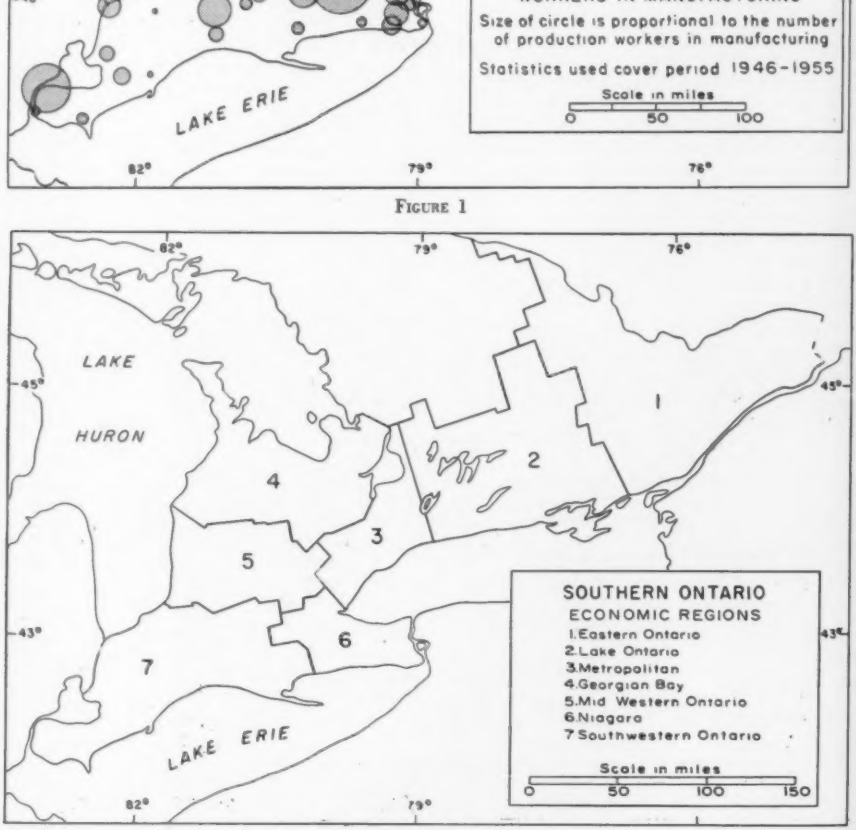


FIGURE 2

market or not, pass through the hands of distributors, and consequently are tabulated in the statistics on wholesale trade. Thus, the largest number of manufactured goods are accounted for. Moreover, a great deal of purchasing by retailers is done at central points. To illustrate, a chain clothing store may purchase nearly all of its goods via its head office in Montreal, which would, in such a case, be the market and not, for example, Calgary where the goods may be retailed. Therefore, of greatest value and accounting for most trade in manufactured goods are the statistics on wholesaling recorded in the Census of Canada every ten years.

However, there are limitations as well, one of which is the unavoidable duplication of statistics. Furthermore, goods not produced in Canada, and goods not deriving from manufacturing are included. Nevertheless, in spite of these drawbacks, wholesale trade is the most realistic indicator of the relative importance of the market for manufacturing.

It was mentioned above that a manufacturer's accessibility to a particular market could be defined most satisfactorily in terms of transportation costs. This being true, the authors decided that the best method of defining the role of the market was to employ the concept of market potential first used by C. D. Harris[7] for the United States. His work follows that of John Q. Stewart[8] who introduced the concept of population potential. Market potential is an index of the intensity of possible contacts with markets and is calculated for a given city by making a summation of the market potentials for that city within the area under consideration, in this instance southern Ontario and Quebec.

The market potentials for 15 communities in southern Ontario and for the City of Montreal have been computed by applying the formula $P = M/d$, where P is the market potential, M the wholesale sales by counties in southern Ontario and southern Quebec, and d actual transport trucking rates in cents per hundred pounds.[9]

The map of market potential (Figure 3) indicates that Metropolitan Montreal and

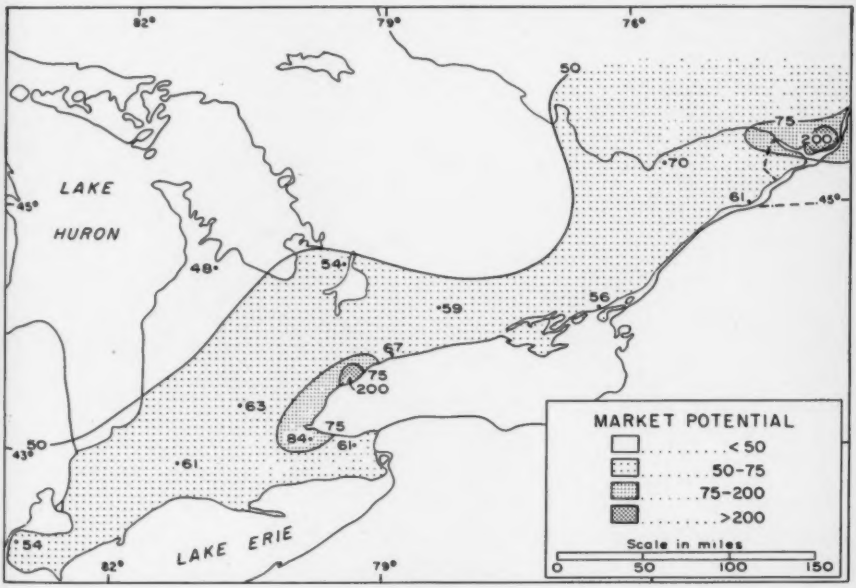


FIGURE 3

Toronto are by far the most important markets in Central Canada.[10] Values of market potential drop off very abruptly at the boundary of each of these two cities, and are very much lower, though remarkably uniform throughout the rest of southern Ontario. At first glance, it is rather surprising that the area between Toronto and Montreal does not have higher values, especially in view of the fact that in the United States, the industrial area between New York and Chicago maintains relatively high values of market potential.

If a manufacturer were guided by considerations of market potential only, he would prefer either Montreal or Toronto as a location for his factory. On the other hand, having avoided the two metropolitan centres, he could in terms of market potential select any community in southern Ontario, values between such widely scattered places as St. Catharines, London, Peterborough and Cornwall being remarkably similar.

With respect to actual transport costs of a manufacturer serving the market in southern Ontario and the St. Lawrence Lowland, Figure 4 has been constructed on the basis of $T = (Md)$, where T is the total transport costs for a given place, M the wholesale trade in each county of the market area under consideration, and d the trucking rates (see above). The costs of distributing goods to this market are lowest in Montreal and Toronto, indices falling off rather abruptly to the north but remaining quite uniform throughout most of southern Ontario. From the point of view of transport costs, the location half way between Montreal and Toronto is much less significant than is generally assumed. Table II demonstrates that transportation rates are not necessarily favourable for the intermediate area.

If a manufacturer has a fairly high percentage of his market in both Montreal and Toronto, he finds it advantageous to locate in one city or the other and not halfway between. To ship 100 pounds by transport truck from Kingston to Montreal and 100 pounds from Kingston to Toronto costs $2.88. To ship 100 pounds from Toronto to Montreal (Montreal to Toronto)

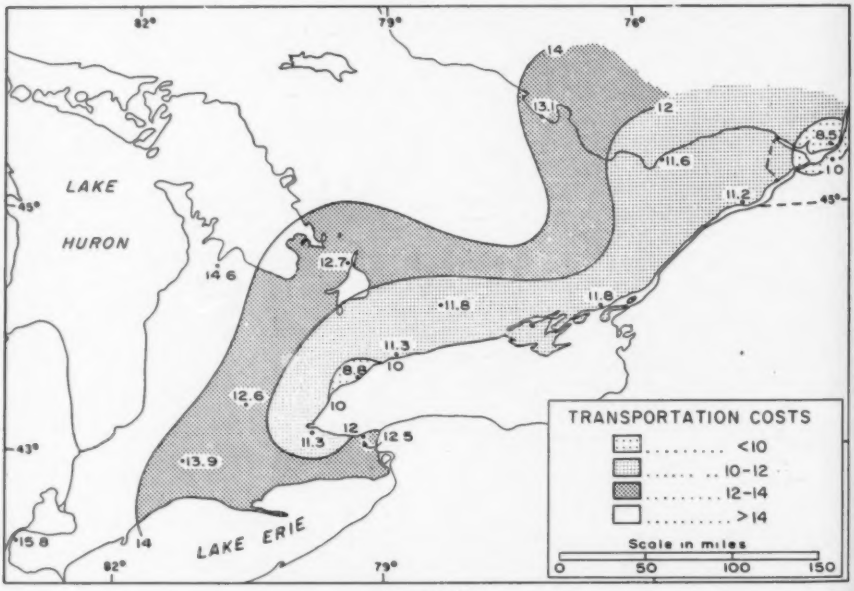


FIGURE 4

TABLE II

Truck Transport Rates in cents per hundred pounds of First Class Freight, July 1957.[11]

Route			Rate
Kingston	to	Toronto	$1.38
Kingston	to	Montreal	1.50
Toronto	to	Montreal	1.64
Montreal	to	Toronto	1.64

and 100 pounds within the City of Toronto (Montreal) costs $1.77, made up of transport costs to Montreal (Toronto) (1.64) and cartage costs within the City of Toronto (Montreal) (13¢), the saving on a 200 pound shipment being $1.11.

It bears repetition that on the basis of market potential and transport costs, exclusively market orientated industries will find locations in either Montreal or Toronto most attractive; elsewhere industries are "footloose" over a wide area. In short, computed values of market potential and transport costs suggest that there is at least a theoretical basis for a much more equitable distribution of manufacturing in southern Ontario than is the case at present. To be more specific, eastern Ontario has the same market potential and even better transport cost indices than southwestern Ontario, and the added advantage of overnight delivery to both Montreal and Toronto. One would expect this region to support at least as much industry as southwestern Ontario. Table I shows, however, that between 1947 and 1956 the counties in eastern Ontario had a smaller increase in manufacturing employment, number of plants, and new plants than those in western Ontario.

LABOUR

A manufacturer's decision to select one community rather than another for his factory is often influenced by either labour costs or labour stability or both. In southern Ontario there is considerable regional variation in the costs of labour.

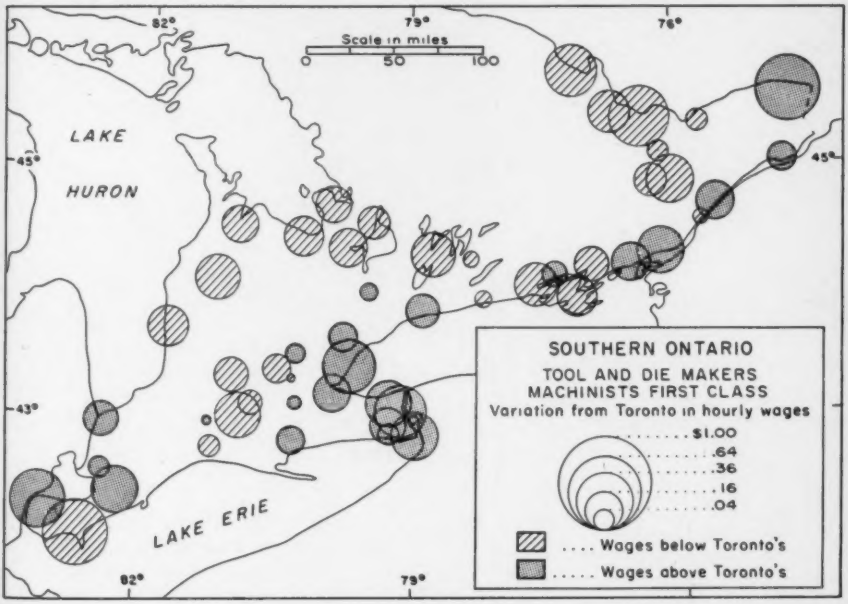


FIGURE 5

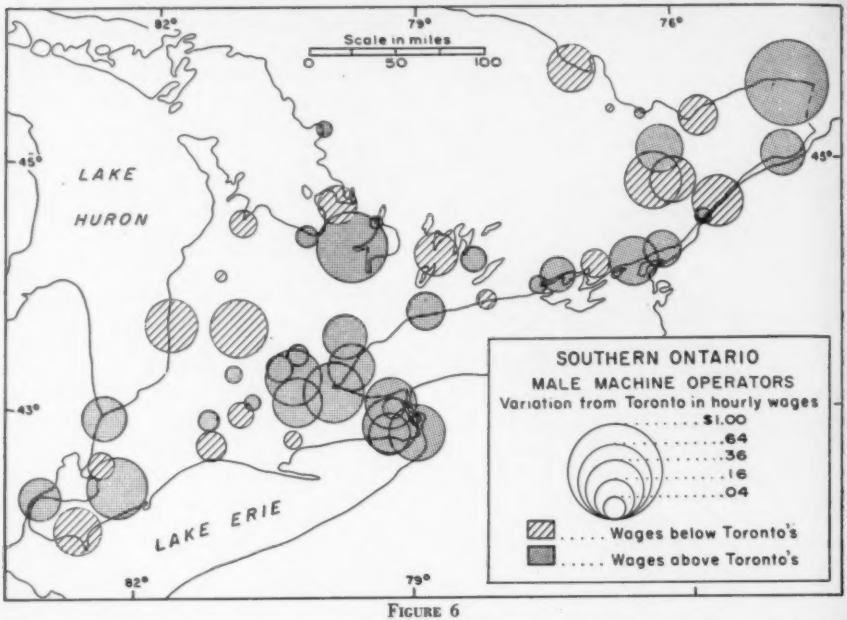


FIGURE 6

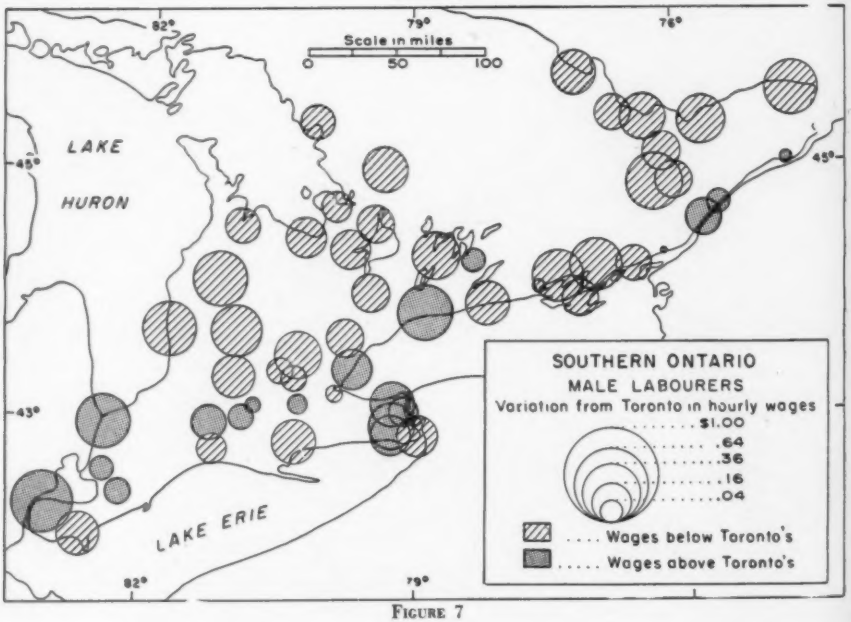


FIGURE 7

TABLE III

REGIONAL VARIATIONS IN HOURLY WAGES FOR SELECTED OCCUPATIONS IN SOUTHERN ONTARIO IN JULY, 1957[14]

Occupation*	Tool & Die Makers	Machinists 1st Class	Machine Operators Heavy	Female Assemblers	Labourers	Carpenters	Plumbers	Female Stenos 1st Class**	Female Typists**	Female Gen. Clerks**	Shippers**	Truck Drivers
Windsor	2.38	2.20	1.75	—	1.68	2.22	2.65	1.19	1.07	0.83	1.13	1.60
London	2.00	1.86	1.71	1.16	1.52	2.12	2.40	1.37	1.14	0.92	1.59	1.63
Owen Sound	1.69	1.85	1.22	1.11	1.00	1.70	1.27	1.22	1.00	1.00	1.55	1.38
Orillia	1.90	1.74	1.60	0.87	1.30	1.75	1.80	1.38	1.10	0.97	1.50	1.40
St. Catharines	2.25	2.05	1.80	1.50	1.60	2.22	2.40	1.37	1.25	1.13	1.60	1.41
Kitchener	1.92	1.75	1.65	0.72	1.38	2.05	2.30	1.20	0.92	0.92	1.20	1.52
Hamilton	2.15	2.00	1.85	1.07	1.45	2.20	2.45	1.29	0.96	0.84	1.25	1.54
Toronto	2.20	1.85	1.50	1.02	1.45	2.35	2.15	1.40	1.17	1.03	1.53	1.32
Oshawa	2.01	2.06	1.80	0.96	1.68	2.25	2.75	1.36	1.10	0.97	1.36	1.35
Peterborough	2.10	1.70	1.54	1.30	1.35	1.90	2.25	1.31	1.12	1.09	1.45	1.13
Kingston	2.20	2.00	1.84	—	1.25	2.15	2.20	1.48	1.21	1.08	1.89	1.25
Ottawa	2.00	1.75	1.37	—	1.10	1.92	2.25	1.44	1.18	1.22	1.19	0.97
Pembroke	1.60	1.60	1.25	—	1.13	1.90	2.10	1.28	1.14	0.97	1.25	1.18
Cornwall	2.10	1.92	1.67	—	1.37	2.17	2.17	1.29	0.86	0.84	1.43	1.17

* Males unless otherwise stated. Wherever applicable union rates rather than non-union rates are given.
** Hourly wages have been converted from weekly wages, the number of hours per week worked being considered.

Furthermore, some communities have experienced long and costly strikes creating, from the manufacturer's point of view, unfavourable labour conditions, whereas other communities have been affected by few, if any, strikes.

The problem of choosing an appropriate yardstick for measuring wage differentials by area has been discussed by H. H. Morritt.[12] He concludes that wages for different occupations in manufacturing computed on an hourly basis express the actual labour costs most realistically. Average weekly or yearly earnings may be affected by changing working schedules, disruption by strikes or seasonal unemployment. It is the hourly wage that the prospective manufacturer appraises, because this reveals to him the wage level of the community.[13]

There are many different occupations in manufacturing and regional comparisons of all would be entirely impossible. Some industries demand specific types of workers and are restricted to only a few communities. Other occupations are quite widespread and form a good basis for regional comparisons. Even so, precise comparisons are not always possible, since, for example, a machinist grade 2 working in a textile mill in Galt may have somewhat different duties from those of a machinist grade 2 working in an aircraft plant in Toronto. For the most part, the problem of regional comparison of wages can be solved by analysing the statistics prepared by the Unemployment Insurance Commission which has categorized occupations in manufacturing, and each month publishes hourly wages for at least 64 communities in southern Ontario.

Table III shows that wages in the same occupation vary greatly from one community to another. Furthermore, a community may record high wages in one category of employment and relatively low wages in another. Such discrepancies add to the difficulty of comparative studies. Four maps (Figures 5, 6, 7, 8) have been prepared to illustrate the regional variation in wage rates in southern Ontario, expressing local wages in values above or below those of Toronto. This decision was based on field studies which suggested that most companies contemplating a location in southern Ontario compare and contrast labour costs in Toronto with those in other communities.

Rates for skilled labour (Figure 5) are relatively low through most of eastern Ontario, central Ontario and the Middle Grand River area. In the Niagara-Hamilton area and in the extreme southwestern part of Ontario, rates are generally higher than those of Toronto. With respect to semi-skilled labour (Figure 6), apart from a few communities in eastern Ontario, the Georgian Bay region and western Ontario, hourly wages throughout southern Ontario are higher than those of Toronto. On the other hand, wages for male labourers (Figure 7) are lower, except for a few towns and cities, especially in the Niagara region and the Windsor area. In many ways the job of labourer is the most representative for labour costs, because "labouring work is reasonably uniform in its low requirements of experience and responsibility so that variations in rates are most likely due to factors other than skill, training, or ability."[14]

On the basis of these maps, it may be concluded that eastern Ontario and the Georgian Bay region have generally low rates, in contrast to the Niagara-Hamilton area and extreme southwestern Ontario where rates are consistently higher than those of Toronto. Female labour costs are higher than those of Toronto throughout nearly all of southern Ontario (Figure 8).

Cost is by no means the only factor a manufacturer appraises when analysing the labour environment of a community. Of considerable significance is the history of labour-management relations in a town or city, as shown by the number of strikes and lock-outs. This can be expressed numerically by relating the number of man working days lost through strikes[16] to the number of production workers[17] over a certain period. This numerical value, called the labour stability index (Ls), is derived by dividing the number of lost working days (x) by the average number of workers during the period under consideration (y): $Ls = x/y$. Statistics were gathered for 84 communities in southern Ontario covering the period 1946 to 1955,

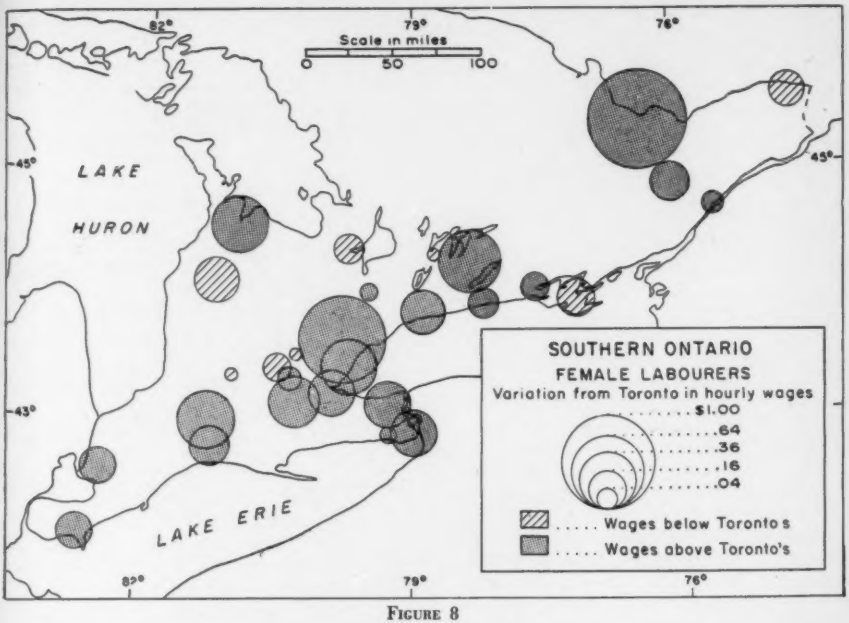


FIGURE 8

and labour stability indices were calculated, values ranging from 0 (no strikes) to over six (Figure 9).

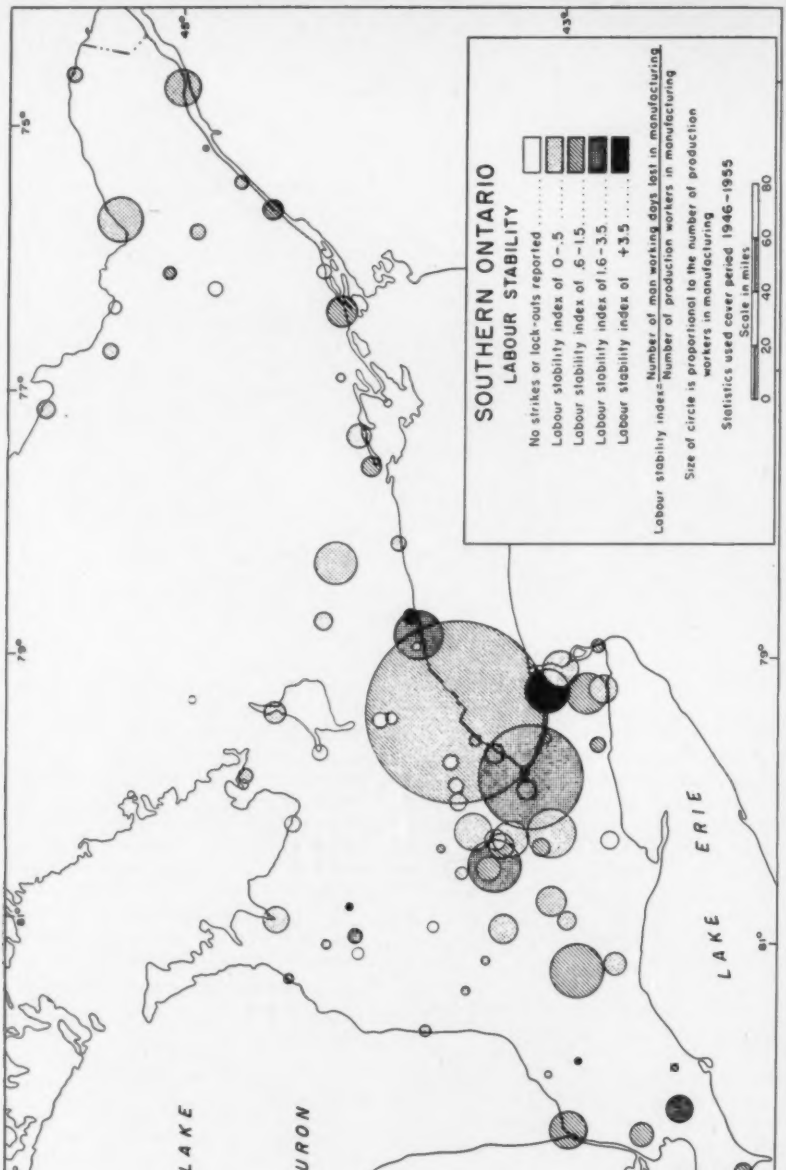
Towns and cities in eastern Ontario, the Georgian Bay region and the Middle Grand River area have the lowest values. Among the medium sized communities, Windsor, St. Catharines, Oshawa, Chatham, Kitchener and Hamilton have the highest instability. The computed value of 1.25 for Metropolitan Toronto is remarkably low considering the great concentration of industries in this area.

From the foregoing analysis of market accessibility, labour costs, and labour stability, two main conclusions may be drawn. In the first place, Metropolitan Toronto has a superior position in nearly all aspects and the large industrial expansion of this area seems to be well justified on the basis of the market and labour factors discussed so far.

Secondly, outside Metropolitan Toronto the degree of industrial expansion by regions does not conform in all respects with the regional pattern of the aforementioned factors. Take the case of eastern Ontario where accessibility to markets combines with relatively low labour costs and high labour stability to present an environment very suitable for industrial expansion. Yet recently its industrial growth has lagged behind that of other regions. On the other hand, certain communities in southwestern Ontario, having a market accessibility somewhat less favourable than that of eastern Ontario, higher labour costs and higher labour instability have experienced a remarkable post-war expansion. It is obvious that other factors exert a great influence on industrial location.

OTHER FACTORS

It is not the purpose of this paper to engage in an intensive analysis of the effect of other factors of industrial location, their complexity demanding more thorough study than is possible at this time. However, on the basis of interviews throughout southern Ontario, in particular


SOUTHERN ONTARIO
LABOUR STABILITY
No strikes or lock-outs reported
Labour stability index of 0-.5
Labour stability index of .6-1.5
Labour stability index of 1.6-3.5
Labour stability index of +3.5
Labour stability index= Number of man working days lost in manufacturing / Number of production workers in manufacturing
Size of circle is proportional to the number of production workers in manufacturing
Statistics used cover period 1946-1955
Scale in miles
0 20 40 60 80
LAKE HURON
LAKE ERIE
45°
44°
43°
82°
81°
80°
79°
78°
77°
76°
75°

with recently established industries coming from other provinces, the United States or Europe, it is possible to point out general relationships. By and large, two questions must be considered: what prompts a manufacturer to choose a small to medium sized community in preference to Metropolitan Toronto, and, once having made this decision, what influences his final choice ?

Firstly, in comparing Toronto with other communities, manufacturers emphasize the friendliness, strong loyalty towards industry, co-operation and enthusiasm in smaller centres where a plant is not just another industry. The general dislike of the large city with its tiresome journey to and from work, overcrowded conditions and polluted air is frequently mentioned. Manufacturers point to the absence of labour unions and argue that labour in small communities is more conscientious and co-operative.[18]

Furthermore nearby rural areas offer ample supplies of labour which can be easily trained having no preconceived ideas.[19] Some think that competition for labour, particularly skilled labour, is less than in the larger centres. Most manufacturers stress emphatically the advantage of lower land costs in smaller communities.

With regard to the manufacturer's choice among several centres of similar size, the following comments can be made. A few industries have special requirements, and their location may be determined by one of the following: the quantity, quality and temperature of water, deep water transport, airport facilities, source of materials or a highly localized market. In a few cases, the size of the town to be selected may be determined by the number of employees a new firm wishes to hire.

The cost of electric power has little influence in the location of industry in southern Ontario although there are substantial variations in cost from one community to another (see Table IV). On the average, power constitutes only three percent of the total production costs in most manufacturing industries. Contrary to most opinion, a location near a generating station offers no significant advantage.

TABLE IV[20]

Net Monthly Bill for use of 1 kw of Industrial Power for 200 hrs. (Rates in Effect Dec. 31, 1957)

Municipality	$	Municipality	$
Niagara Falls	2.70	Windsor	2.70
St. Catharines	2.79	Owen Sound	2.34
Hamilton	2.29	Belleville	2.07
Kitchener	2.92	Brockville	2.38
Guelph	2.34	Iroquois	3.00
Toronto	2.91	Ottawa	2.61

Of great importance is the attitude of towns towards industry which, surprisingly enough, may be sharply contrasted even within small areas. Some towns maintain a tradition of vigorous industrial activity and promote industrial expansion by advertising, providing properly serviced land, and displaying enthusiasm for manufacturing. On the other hand, there are towns which limit expansion, probably to avoid increased expenditures or to leave the local labour market undisturbed. Existing industries may look unfavourably upon the arrival of a large industry. Manufacturers frequently mentioned that initiative of a town or region had influenced them profoundly in their decision. In this respect the industrial commissioner plays a role which, of all the factors affecting the location of industry, is the most difficult to define. He may be thought of as a medium through which the prospective industrialist comes in contact with the community, and it is his responsibility to expand its industrial base. Undoubtedly an intelligent and enthusiastic industrial commissioner greatly aids a community in its quest for industry.

Several towns may offer similar economic advantages but the choice of one over the other may be determined by the personal reaction of the company official charged with the responsibility of choosing a plant location. Examples are educational facilities, such as university and technical schools, proximity to a large metropolitan

centre (in the case of Americans, proximity to a large American centre) and recreational facilities offered by the town or the region. In one community, at least four firms were branch plants which had originated in one particular city in Ohio. One of these companies had arrived in 1947 and the others followed in later years, simply because of personal contacts between company officials.

Of great importance is the tendency among manufacturers to locate in or near existing industrial concentrations where the presence and success of other industries is reassuring. This may well be the main reason why existing industrial concentrations continue to expand and weakly industrialized communities stagnate.

CONCLUSIONS AND IMPLICATIONS

Recent industrial development in southern Ontario has favoured some communities and not others. Metropolitan Toronto and its immediate surroundings have experienced a very large growth which has been supported by strong economic forces. Outside of this area, non-economic factors have more significance. It follows that a very large segment of industry is "footloose" over most of southern Ontario. Therefore, a much greater dispersal of industry is possible than has been the case heretofore. This discovery should be of great interest from the point of view of regional planning and development.

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3. Computed by subtracting number of establishments in 1947 from number in 1956. Source: *The Manufacturing Industries of Canada, Section G, Geographical Distribution*, Dominion Bureau of Statistics, Ottawa 1947 and 1956.

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5. Recorded by Trade and Industry Branch, Ontario, Dept. of Planning and Development, Toronto.

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9. The calculation of market potential in southern Ontario and Quebec is based on wholesale sales by counties (1951 Census) and actual transport trucking rates for 100 lbs. of first class freight. The statistics on trucking rates were obtained from the Canadian Transport Tariff Bureau from the following publications :

   1) Class Tariff No. 10-D for Rates between Ontario and Quebec.

   2) Class Tariff No. 1-B for Rates between various points in Ontario.

   The advantages of using wholesale statistics have already been discussed. The transport costs are actual costs of a great variety of goods moved by transport truck on the basis of less than truck load (LTL), and, therefore, approximate reality as closely as possible. In the metropolitan areas of Toronto and Montreal, costs of intra-city shipments are not quoted on the basis of cents per hundred pounds, but rather on cartage rates by the hour. Consequently, it was necessary to average a large number of mythical deliveries. The values estimated are 13 cents per hundred pounds of first class freight. These figures have been confirmed by a number of traffic managers.

10. The map would have changed little, if the Maritime Provinces and western Canada had been included as well. The Maritime market is relatively small while the costs to ship goods by rail from any point in southern Ontario to the same point in western Canada are identical.

11. Canadian Transport Tariff Bureau, *op. cit.*

12. MORRITT, H. H. : *Regional Wage Differentials and the Composition of the Maritime Provinces*, Canadian Political Science Association, Ottawa, 1958 (mimeo).

13. In this study the authors are defining the characteristics of labour in a community according to their advantages and disadvantages for the manufacturer. It may be that the worker in a small to medium sized community, although receiving a smaller wage than his counterpart in a metropolitan area, has many fringe benefits in terms of less expensive housing, lower transportation charges, long term relationship with the company on a more personal level, etc. In more detailed studies, attempting to give a complete picture of the significance of wages to the individual, money wages (income) would have to be compared with real wages (wages in terms of goods).

14. Data obtained from the Toronto Office of the Unemployment Insurance Commission.

15. MORRITT, H. H. : op. cit. See also LESTER, R. : Southern Wage Differentials: Developments, Analysis and Implications; *Southern Econ. J.*, 1947, pp. 386-394, for a general discussion.

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18. This assumption is not justified by the facts, especially if one considers the relatively high labour stability index of Toronto.

19. On the other hand, some manufacturers complain that such training requires too long a period and is too costly.

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TRANSPORTATION OF UNGAVA IRON ORE *

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ABSTRACT. *This paper discusses a mining project which, when completed, may have profound influence on economic development of the whole Canadian Eastern Arctic. Slowness in developing the region has been due, in large measure, to difficulty of access, particularly in winter. This has been reflected in high transportation costs as compared with areas farther south, or in the same latitude on the western margin of the Canadian Shield.*

The most promising location for mining development in the Eastern Arctic in the near future is in the neighbourhood of Hudson Strait. Large iron ore deposits on the west side of Ungava Bay are well located to satisfy part of the growing demand for steel in the nations bordering the North Atlantic. However, mineral development anywhere in the Eastern Arctic is seriously handicapped by a short navigation season which makes it difficult to carry construction materials and equipment to the sites and to ship the products out to markets. In Ungava Bay, the open season is about four months, too short a period to convey sufficient tonnages of ore over the long sea routes to Europe or the Eastern United States.

Entirely apart from transportation, there are other problems to be faced in opening up such an entirely undeveloped region to mining, but they are of a type met with and overcome elsewhere. There is, however, apparently no precedent for a mine needing to export several million tons of ore a year over routes in excess of 2,000 miles, but with a shipping season restricted to so few months. The solution in the case of Ungava Bay is to employ an intermediate transfer station in an ice-free area of West Greenland on the far side of Davis Strait.

The paper describes some of the factors taken into consideration in planning the exploitation of Ungava iron ore, transportation of the concentrate, and in particular the selection of an ice-free port site in Greenland.

This project will, if successful, pioneer the industrialization of northern-most Quebec, but, of perhaps greater long run significance, it should demonstrate a technique by which other mineral deposits in more remote parts of the Eastern Arctic may be brought to world markets at a competitive cost.

RÉSUMÉ. *L'auteur expose ici un projet d'exploitation minière, qui une fois complété, pourrait avoir une influence considérable sur l'évolution économique de l'Arctique oriental. Le retard encouru dans le développement de cette immense région est imputable en grande partie, aux difficultés d'accès particulières à ces régions, surtout durant les longs mois d'hiver. Ces difficultés entraînent inévitablement une hausse des tarifs des transports de beaucoup supérieurs aux régions situées plus au sud, voire même à une latitude semblable à la limite occidentale du Bouclier canadien.*

Les environs du détroit d'Hudson semblent offrir un endroit très prometteur pour une telle exploitation. Les gisements ferrifères de la côte ouest de la baie d'Ungava sont d'autant mieux situés, que l'affluence des demandes pour ce minerai provient des pays limitrophes de l'Atlantique nord. La saison de navigation écourtée en ces régions, complique les envois de matériaux et d'équipement, nécessaires à une telle exploitation, et l'expédition des extractions vers les grands marchés. Ces complications retardent donc outre mesure le développement économique de cette partie du pays. La baie d'Ungava est ouverte à la navigation durant quatre mois par année seulement, période qui n'est pas assez longue pour permettre l'expédition par voie de mer d'un tonnage suffisant à destination de l'Europe et de l'est des Etats-Unis.

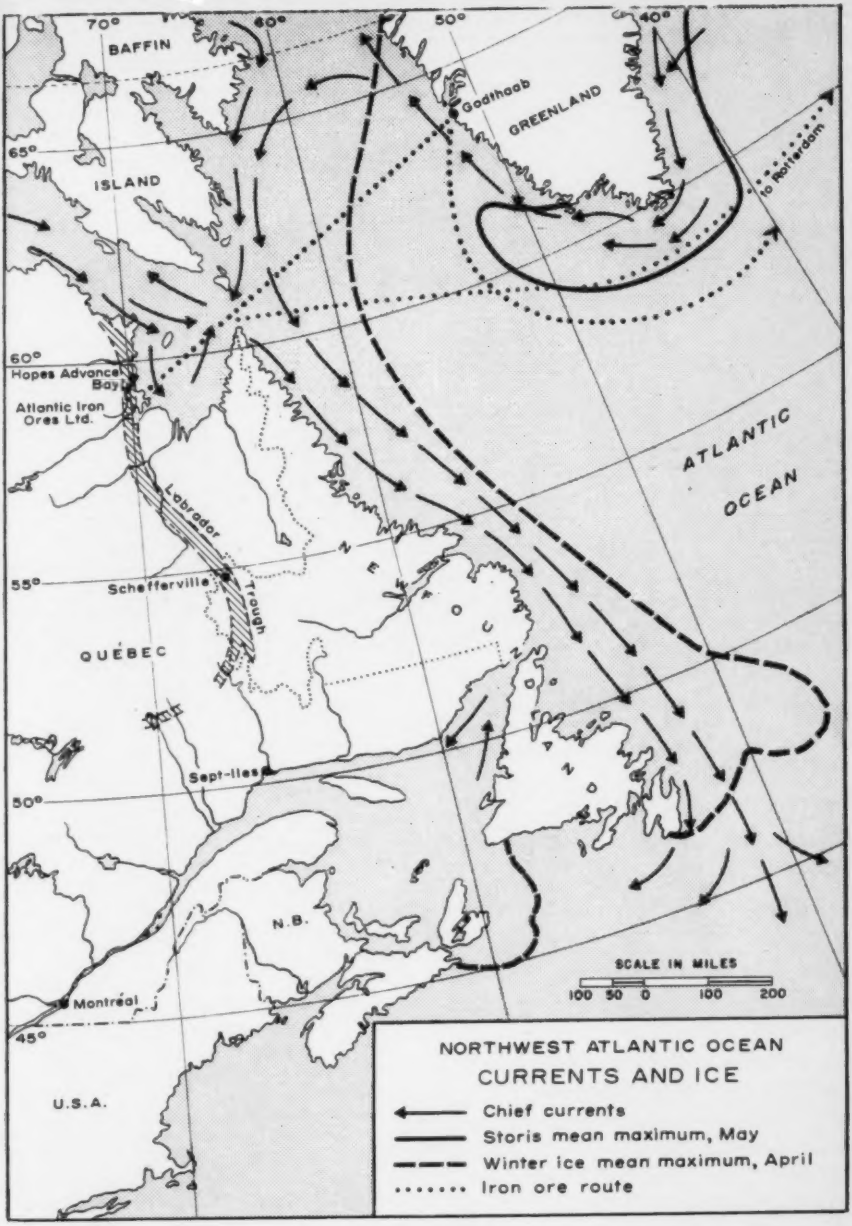
A part du problème des transports, les promoteurs d'un tel projet devront faire face à d'autres problèmes avant d'affranchir ces régions au développement minier. L'expérience a démontré toutefois que ces difficultés peuvent être contournées avec succès. Cependant aucun précédent dans ce domaine ne semble justifier une exploitation minière de plusieurs millions de tonnes par année dans une région située à au-delà de 2,000 milles des marchés les plus proches et ce, pendant une saison navigable de quelques mois seulement. L'installation d'un port de transbordement, libre de glace, sis sur la côte ouest du Groenland près du détroit de Davis résoudrait ce problème qu'est l'exploitation des gisements de la baie d'Ungava.

Cette étude analyse certains facteurs pris en considération lors de la mise en plan de ce projet, tels que le transport des concentrés et le choix d'un site pour un port libre de glace sur le littoral groenlandais.

Ce projet une fois réussi aurait pour effet l'industrialisation du Québec septentrional et la mise au point éventuelle de certaines techniques à partir desquelles d'autres gisements situés en des régions encore plus éloignées de l'est Arctique pourraient être acheminés vers les plus grands marchés mondiaux à un prix permettant d'affronter la concurrence.

This paper discusses a mining project which when completed, may have profound influence on economic development of the whole Canadian Eastern Arctic. The lack of large-scale industrial enterprises in this area is due, in large measure, to difficulty

* Presented at the Ninth Annual Meeting of the Canadian Association of Geographers, Saskatoon, 1959. The authors wish to thank Ungava Iron Ores Company, Montreal, for the use of material from Company reports.


70°
60°
50°
40°
BAFFIN
ISLAND
Godthaab
GREENLAND
to Rotterdam
65°
60°
Hopes Advance Bay
Atlantic Iron Ores Ltd.
Labrador
Trough
ATLANTIC
OCEAN
55°
Schefferville
QUÉBEC
Sept-Iles
50°
N.B.
Montréal
45°
U.S.A.
SCALE IN MILES
100 50 0 100 200
NORTHWEST ATLANTIC OCEAN
CURRENTS AND ICE
Chief currents
Storis mean maximum, May
Winter ice mean maximum, April
Iron ore route

of access, particularly in winter. This has been reflected in high transportation costs as compared with areas farther south, or those in the same latitude in the Mackenzie district on the western margin of the Canadian Shield.

The most promising area for Eastern Arctic mining development in the near future would appear to be in the neighbourhood of Hudson Strait. In particular, large iron ore deposits on the west side of Ungava Bay are well located to satisfy part of the growing demand for steel in nations bordering the North Atlantic. However, mining, along with other enterprises in the Eastern Arctic, is handicapped by the short season of navigation available to carry in construction materials and equipment and to ship out the products. In Ungava Bay, shipping is able to move for only about one-third of the year, a short period in which to export large tonnages of ore by sea to Europe or the Eastern United States. (Figure 1)

Other problems, apart from transportation, may be encountered in opening up to mining such an entirely undeveloped region, but they are of a type met with and overcome elsewhere. So, success of the Ungava enterprise depends in a large measure on the possibility of exporting several million tons of iron ore annually over 2,5000-mile ocean routes during a shipping season restricted to a few months and of doing so at a competitive cost.

THE DEPOSIT

At the western side of Ungava Bay there is a series of iron ore deposits occurring in the geological structure usually known as the "Labrador Trough".[1] The deposits extend north-south for about 200 miles and inland from the coast varying distances up to 30 miles. The Government of

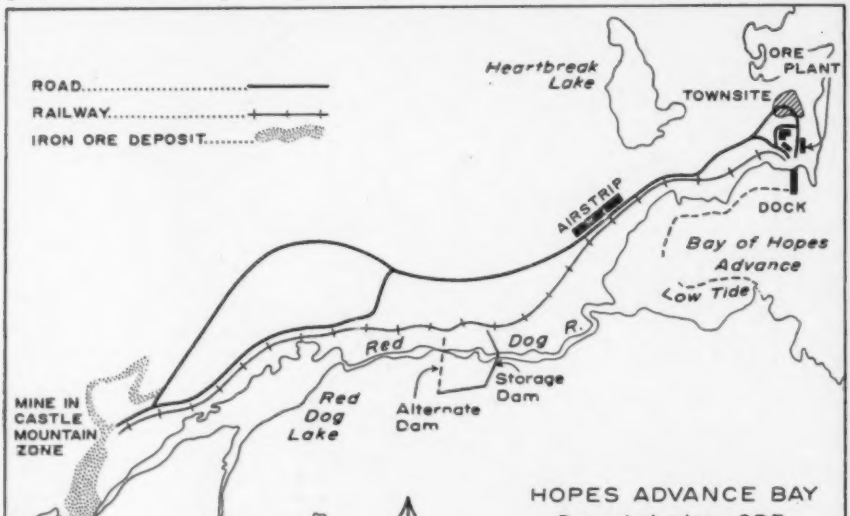


FIGURE 2

Quebec has granted several mineral concessions in the area, the one discussed here being that of Atlantic Iron Ores, Ltd. This concession is under license to Ungava Iron Ores Company which is now (1959) planning to exploit it. Proven ores within the Atlantic concession total about 600 million tons and it is anticipated that further drilling in the western part of the area will increase this to more than a billion (1,000 million) tons. The ore contains both haematite and magnetite and averages between 35% and 36% iron. It is to be mined by open pit methods, concentrated by magnetic roasting and magnetic separation, agglomerated into pellets of about ½ inch diameter containing about 65% iron, and exported in this form.

Although the percentage of iron in the ore as mined is low in comparison with typical "direct shipping" ores such as those from the Mesabi area of Minnesota, from Schefferville, Quebec, and from Kiruna, Sweden, it is not low by comparison with ores which are beneficiated before shipment, such as the taconites of Kirkenes, Norway, and of Minnesota.[2] There is a growing tendency for blast furnace users to prefer pelletized ores, so the product to be shipped from Ungava is expected to find a ready market at a premium price.

PLANNED LOCATION OF THE MINE

The ore deposit that will probably be mined first lies in the Castle Mountain Zone about 20 miles inland from Hopes Advance Bay. Studies by the Hydrographic Service of the Canadian Department of Mines and Technical Surveys made between 1954 and 1956 revealed that Hopes Advance Bay can be reached from the open sea by a deep water channel and that there is a suitable site on the north side of the bay for construction of a port.[3] The land surface there is satisfactory for stockpiling the ore and pellets, for constructing the beneficiation plant and for a townsite capable of housing about 5,000 people, together with schools, churches, stores, public buildings, recreational facilities, central heating, etc. There is ample water for industrial and commercial use. Two headlands — Breakwater Point and Merganser Point — provide some natural protection for the shipping wharves. Air services which will be important, in the absence of regular railway and shipping connections with southern Canada, can use an airfield to be built about 4 miles from the townsite. (Figure 2)

MINING

The ore will be mined from an open pit by drilling and blasting, loaded by electric shovels into 27-ton trucks and transferred to 90-ton gondola railroad cars for conveyance 20 miles to the primary crusher at Hopes Advance Bay. It is expected that weather conditions will permit mining throughout the year.[4]

MARKETS AND TRANSPORTATION

Markets for the iron ore pellets are to be primarily in western Europe, and subsequently also in eastern North America. In Europe the ore will be unloaded at the new "Europort" which is being constructed as an extension of the Port of Rotterdam. From there it will be conveyed up the Rhine by barges to the Ruhr or by cargo vessels to British ports.

Mining and processing of the ore in Ungava are not expected to present unusual technical problems, nor are construction and operation of the plant and townsite expected to be difficult, although they will undoubtedly offer challenging opportunities for engineers, architects and geographers. It was however recognized all along that *transportation* of the ore — probably amounting to a minimum annual shipment of 5 million tons when operating to capacity — would determine the project's economic feasibility. In this connection the major problems to be encountered are likely to be due to climate. Granted the existence of a good harbour readily accessible from the sea, there remain two physical uncertainities — tides and ice. The former are not expected to prove a serious difficulty and shippers believe that vessels can be loaded and unloaded at all states of the tide, even though the rise and fall is as much as 44 feet at Spring Tide. Details are shown in Table I.

TABLE I
TIDAL INFORMATION[5]

Place	Height above Datum of Soundings				
	Large Tides		Average Tides		Mean Sea Level
	Higher H.W.	Lower L.W.	Higher H.W.	Lower L.W.	
	feet	feet	feet	feet	feet
Hopes Advance Bay	44.4	0.4	36.1	8.6	22.3

Tidal currents are strong in Hudson Strait, but at the docksite are negligible.

Ice conditions are however another matter.[6] Sea ice of three distinct origins is encountered in the area, and information about it based on direct observation is still far from adequate. Winter ice forms within Hopes Advance Bay itself and within Ungava Bay, and is believed to extend offshore more or less continuously for perhaps 10 miles. Beyond this there usually lies an area of moving pack-ice. Ice originating in Foxe Basin, Hudson Bay and Hudson Strait when moving eastward toward the Atlantic enters Ungava Bay and circulates anti-clockwise. The third source of ice is the Baffin Bay pack-ice moving southward. This heavy pack often flows westward along the north shore of Hudson Strait and always closes the eastern entrance to Hudson Strait in early winter, thus cutting off the sea route between Ungava Bay and Davis Strait leading to the North Atlantic. In addition another category of ice — icebergs — is encountered at the eastern entrance to Hudson Strait. These icebergs drift southward with the Labrador Current. It is believed, on the basis of still very limited data, that Hopes Advance Bay may be open to navigation from Davis Strait by strengthened vessels[7] for 120-130 days, but possibly, though not probably, in some seasons for as little as 90 days. The typical navigation season is believed to begin about July 20 with the freeing of Ungava Bay from ice, and to close when the Baffin Bay pack seals the eastern end of Hudson Strait. This closing may be as early as November 20 or possibly as late as December 1. There is urgent need for systematic ice observation and hydrographic studies of the area over a period of years, particularly in late October, November and December to determine more precisely the date and manner of the close of navigation.

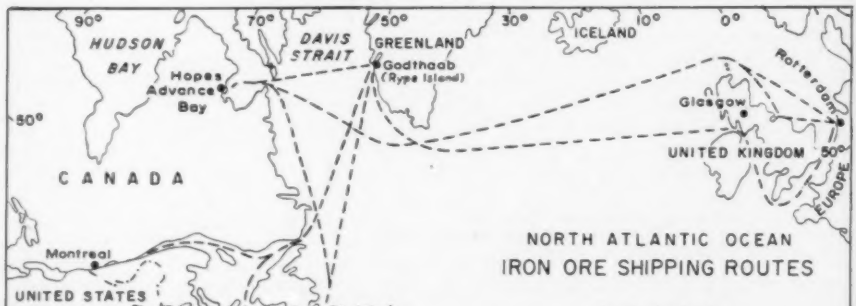


FIGURE 3

SHIPPING

The distance from Hopes Advance Bay to Rotterdam is about 2,650 nautical miles and that to Baltimore about 150 nautical miles shorter.[8] It is anticipated that the iron ore pellets will be exported in specially constructed carriers of about 70,000 tons, requiring a draft of about 42 feet. The vessels will probably be equipped with self-unloading gear capable of handling about 8,000 tons of pellets per hour. Loading equipment will be provided onshore. The vessels will be strengthened against incidental contact with ice, although there is no intention of using them to navigate in pack-ice, since the shipping plan discussed below makes this unnecessary. It is recognized that loose pack-ice may be found on the western (Canadian) side of Davis Strait and that there are scattered icebergs. These conditions should not be a hazard to large ships equipped with modern radar and other ice-detection devices and aided by regular ice surveys and forecasts. In late 1959, the Danish government inaugurated a system of ice reconnaissance and forecasting. Based on the airport at Narssarssuaq in Southern Greenland, it is to be coordinated with the work of the Canadian Ice Central at Halifax and with the International Ice Patrol.

Ships operating in North Atlantic waters off Greenland have at times experienced severe "icing" of the decks and rigging. This is probably mainly a problem for relatively small ships, but it deserves attention.

TRANSPORTATION PLAN

An iron ore shipping plan, to be successful, must permit 5,000,000 tons of pellets to be shipped from Hopes Advance Bay in the 120 or fewer days during the summer season when the route is practically free from ice.

Two alternative methods appear to be possible: One is to ship the annual production of ore direct to overseas markets within the limited ice-free period. This presents several disadvantages — it has been estimated that eleven very large vessels would be needed; and they would need to find employment elsewhere during the 8 months of the year when not engaged in the Ungava trade;[9] large stockpiles of ore would need to be accumulated at the overseas receiving point during the short shipping season.

The second possibility is to export the 5,000,000 tons of pellets from Hopes Advance Bay during the ice-free season for stockpiling at an intermediate ice-free site, whence they could be transferred to overseas markets continuously during the remainder of the year. This method would employ fewer ships (probably four), ensure regular use of them throughout the year, and provide overseas buyers with a steady flow of ore. A disadvantage would be the cost of constructing and operating the transfer port. Success of the plan would depend on finding a suitable transfer port-site, and on balancing the added cost against improved service.

The basic requirements for the transfer port-site are: that it is not too far from Hopes Advance Bay, that it is ice-free throughout the year, that a readily accessible deep-water harbour is available, and that the terrain is suitable for pellet storage.

There appear to be only two possible locations:

a) The east coast of Canada sufficiently far south to be ice-free;

b) The west coast of Greenland.

Ice conditions determine that no suitable site can be found in Canada nearer than the south shore of Newfoundland, and that even there ice may in some years interrupt shipping for some weeks early in the years.[10] An additional objection is that the distance from Hopes Advance Bay to western Europe is increased from 2,650 miles to 3,700 miles by making a call at Newfoundland, which lies well south of the direct route. Furthermore the laws of "cabotage" would require the use of Canadian or British flag vessels on the voyage from Hopes Advance Bay to a Newfoundland transfer point since both are within Canada, in this way making shipping arrangements less flexible.

It is believed that a transfer port in southwest Greenland offers the only practical solution of the shipping problem.

Choice of a site there depends on three main considerations:

1) Selecting a part of the coast free from ice at all seasons.
2) Locating an accessible deep water harbour with sufficient level ground nearby and other desirable physical characteristics.
3) Securing co-operation of the Danish authorities for establishment of an industrial activity without precedent in Greenland.

ICE CONDITIONS IN SOUTHWEST GREENLAND

While a considerable part of the southwest Greenland coast is usually referred to as "ice free", this is strictly true of only specific stretches and in most cases for certain times of the year. Four types of ice must be taken into consideration. During the late winter, local ice[11] often forms in deep bays and at the heads of fjords even in the far south. For example, the air base at Narssarssuaq (BW 1) which is at the head of a long fjord is often inaccessible by sea in mid-winter. However, such ice is not significant on the *outer* coast because of the different hydrographical conditions including the intrusion of warm Atlantic surface water in early winter and the effects of stormy weather. The open sea off Godthaab for example does not freeze.

The second type of ice is known in Greenland as "West Ice"; it forms over Baffin Bay and the western or Canadian side of Davis Strait in winter and reaches a maximum in March. Its southern limit on the Greenland coast is usually near the Arctic Circle and it is not believed to extend as far south as the latitude of Godthaab, about 64° N.

The third ice type is, curiously enough, a hazard mainly in spring and early summer. This consists of heavy polar pack-ice ("Storis") which flows southward along the Greenland east coast, rounds Cape Farewell and is carried northward along the west coast by the current.[12] It is invariably found in Spring in southernmost Greenland but very rarely in recent years as far north as Godthaab. — in fact it has only been carried this far north for a few days five times in the past 50 years. The "storis" is thus a spring and summer hazard and increases in severity toward the south.

The fourth ice type consists of pieces of land ice, in the shape of icebergs, most of which originate in east Greenland and are carried along the same route as the "storis". Some small bergs originate in southwest Greenland. Icebergs are usually scattered, drift northward fairly close inshore and are, when large, readily detected. However they remain a hazard when low in the water particularly in foggy or stormy weather.

It is particularly difficult to estimate future ice conditions in west Greenland waters because ice distribution has changed considerably during the present century. This is doubtless related to rising temperature of the sea locally and also to fairly widespread modifications in climate both atmospheric and marine.[13] In estimating the long range influence of ice on shipping it is safest to assume an eventual return of Greenland water temperatures to those existing at the turn of the present century, and to allow for an increase in "storis" distribution to its observed maximum during the past sixty years. This is necessary because the long-term success of a commercial shipping route in these waters would depend not on *average* conditions over a period of years, but on the *extreme* conditions in the worst year — during which regular shipping might be seriously interrupted or insurance rates might be affected. Fortunately the waters of southwest Greenland have been in regular use for many years, and surprises are most improbable. Any interruption to shipping by ice except during winter in the north and spring-summer in the far south would be unlikely to extend beyond a few days. The risk of ice interfering with shipping lies at the Ungava end of the route, in comparison with which the Greenland risk is negligible.

The search for a port-site in West Greenland suitable for development for year round iron ore shipping began in 1955 with study of available ice records. In addition to using published material it was necessary to consult local opinion,

particularly that of long term residents of strategically placed coastal settlements. It was concluded that the port should not be farther north than Godthaab Fjord[14] or farther south than Ivigtut, where an interruption of navigation due to "storis" for several weeks in early summer must be expected. The stretch of coast where a harbor should be sought lies therefore between about 64° N. Lat. and 61° N. Lat. — an overall distance of about 200 miles. This area extends as far south as is possible with reasonable assurance of freedom from "storis". From what has already been stated it was concluded that the harbour site should be near the outer coast to avoid formation of winter ice. However, the prevalence of coastal fog in summer suggests that the port should not be farther out than is necessary.[15]

LOCATION OF POSSIBLE PORT-SITE

The technique used to locate possible port-sites was as follows: Using all available maps and charts, air photography, hydrographic and ice reports, pilot books and their personal experience of the area, the authors prepared a preliminary list of sites to be examined, and assembled the necessary charts, photographs, etc. in each case. They selected more than thirty possible sites, although only a few were expected to deserve intensive study. The characteristics sought for such port-sites were mainly these:

Navigation. The prime requirement was that large vessels should be able to enter the port, manoeuvre, dock and undock rapidly under all conditions of weather, light and visibility. A safe and direct route to the port from the open sea was highly desirable.

Weather and Climate. While conditions along the whole of the 200 mile stretch of the outer coast under consideration are more or less uniform, local variations due to differences in topography or siting may be significant. For example, strong föhn winds are very localized. The incidence of fog and "freeze-thaw" conditions have already been mentioned. Local weather peculiarities might affect not only movement of ships, but also stockpiling of pellets, construction of loading gear and associated facilities, mechanical operation of the plant throughout the year; and the movement of personnel to and from the port. Hence, although West Greenland is in general well provided with meteorological stations, some of which have long records,[16] selection of a port-site even a few miles from a station would make it necessary to carry out supplementary weather observations at the actual site, before making final engineering plans. Particular attention would need to be given to direction and force of winds, depth of snow, pattern of snow drift, and sea water temperatures as well as the usual synoptic readings.

Terrain. A considerable area of reasonably level, solid terrain is needed for stockpiling the heavy pellets and for laying out the conveyors, for construction of associated buildings and possibly for a small town-site. Run-off from melting snow in spring must be considered, together with the possibility of flooding underground conveyors. Construction materials, particularly sand and gravel are required.

Socio-political Factors. Many "social" questions also need to be considered before locating an industrial enterprise in a relatively undeveloped region such as Greenland. For example, it may be advantageous to build near an existing settlement, or alternatively, isolation may be desirable or even mandatory. Also to be considered are sources of local labour, and the impact a large enterprise might have on the existing social structure and on other employers of local labour.[17]

THE SEARCH FOR A SITE

Field studies of possible port-sites were carried out by a team based on the research vessel *Blue Dolphin* under command of Commander David C. Nutt.[18] The team arrived in West Greenland on June 30, 1956 and remained there until the end of August. They examined the coast from near Ivigtut in the south to Godthaab Fjord in the north, twenty-nine sites being visited. Every effort was made to benefit from local knowledge. The Danish authorities seconded to the party an engineer and a senior ship's captain familiar with the

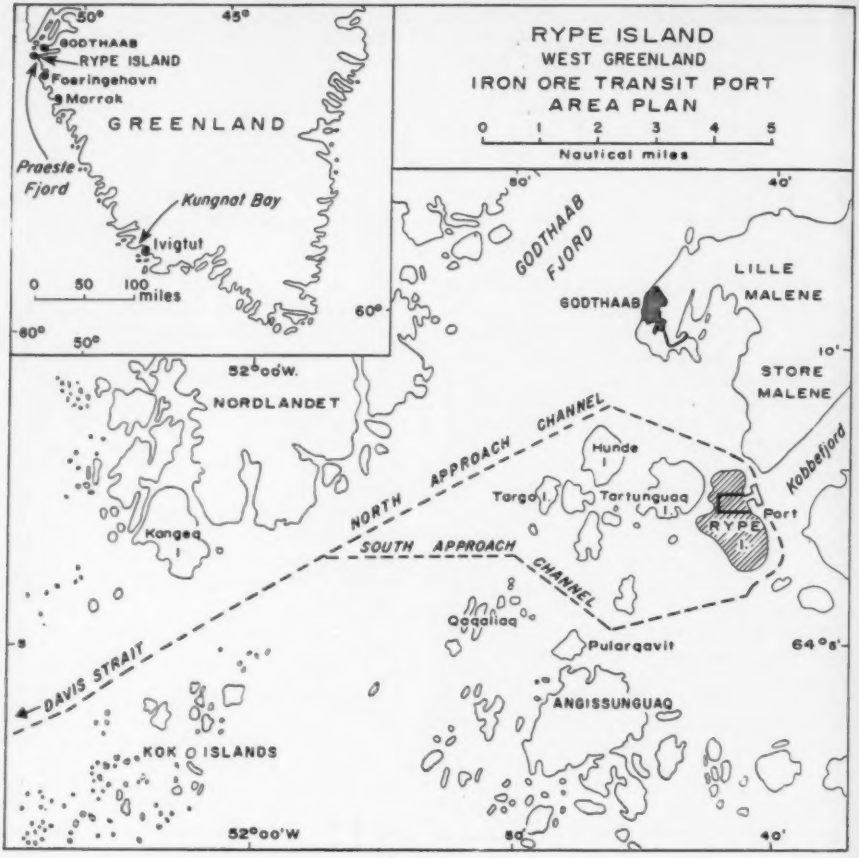


FIGURE 4

coast, as well as a young Greenlander as general assistant. Five sites were selected for more intensive study and a detailed analysis was made of each. Maps of the terrain, hydrographic charts, suggested layouts for wharves, stockpiles, etc. were prepared in the field. Four of the selected sites were in the northern portion of the area being studied, while the fifth, at Kungnat Bay, near Ivigtut was in the far south. While this site had the great advantage of a good and well-known approach from the sea, satisfactory terrain, and close relations with the long-established mining community at Ivigtut, it was eventually excluded because of the likelihood of "storis" between March and early July.

The four remaining sites, none of which met all requirements fully, provided interesting contrasts. Beginning on the north they were:

1. *Rype Island*[19] which lies four miles south-southeast of Godthaab, the Greenland capital, in an area which has been well-known to sailors for more than two centuries. The open sea there does not freeze and storis is very rare. A few small icebergs may occasionally drift into nearby waters from the open sea or from

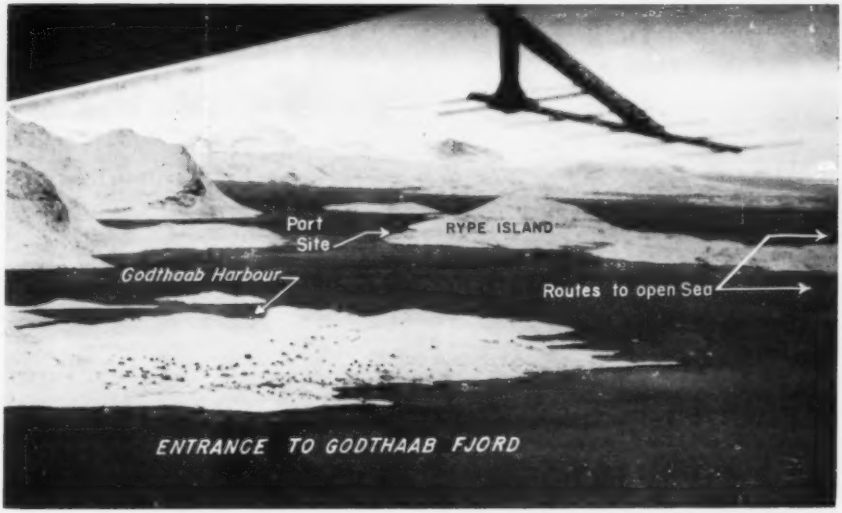


FIGURE 5. Rype Island, Greenland, in relation to Godthaab settlement in lake October 1944 before the growth of Godthaab to its present size. (R.C.A.F. photo RE 2072-16).

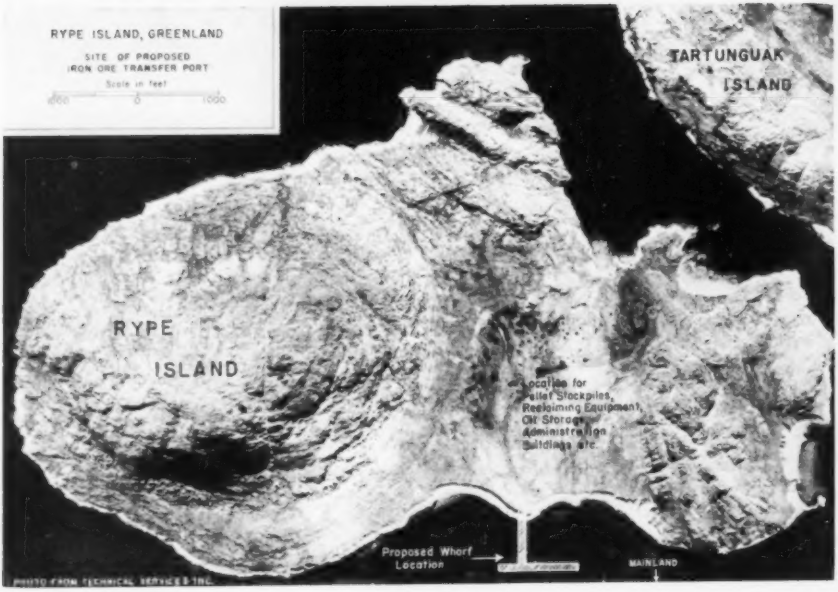


FIGURE 6

FIGURE 7. Rype Island, looking northwest across the port area.

Godthaab Fjord. The island, which is about 1½ miles long by ¾ mile wide, has two rocky hills separated by a more or less level stretch of moraine and fluvioglacial material. Although there is little or no fresh water supply on the island itself, there is ample on the mainland nearby. Tides average about 9 feet. The site selected for a wharf is partially sheltered from southwest winds by a hill. Because the port-site is near Godthaab, the personnel could make their homes there and "commute" by boat. A good navigation channel to and from the open sea was found by *Blue Dolphin* but needed confirmation by more detailed surveys. (Figures 4 and 5)

2. *Praestefjord.* This is a small inlet about 15 miles southeast of Rype Island on the south side of the large Ameralik Fjord near its entrance. It was selected in the 1720's by the missionary Hans Egede, founder of modern Greenland, as the site of a settlement but was ruled out of consideration on orders from Copenhagen because winter ice forms within it and Godthaab was chosen instead. The regular use of large ore vessels in the fjord would probably reduce the amount of winter ice. Terrain, water supply and other characteristics appeared suitable in 1956. Because of the distance from Godthaab a separate townsite would be needed.

3. *Faeringehavn.* When, about 25 years ago, a port was needed for use by the international fishing fleet which operates off the West Greenland coast in Summer, this inlet about 30 miles south of Godthaab was chosen. It is now a modern fishing port with a 1,000-foot wharf, large warehouses, a hospital, oil tanks, and stores for supplying the fleet with food and other necessities. Several thousand fishermen call there each summer. Although 10,000-ton ships reguarly use the port in summer it was however judged to be too small for large ore carriers. It has a relatively narrow approach channel, but lies close to the open sea and the fishing banks. Winter ice is known to form in the harbour but "storis" is infrequent.

4. *Marraq.* The Eskimo place-name indicates that this site consists of gravel, clay and other fine material, and it is in fact part of a raised terrace. So rare is such a level site along the Greenland coast that it served as an emergency landing field early in World War II. A few temporary buildings were erected, and it appeared on maps as "Teague Field". The stretch of elevated, level land juts out to sea sufficiently far to provide a fairly protected bay on the north side. However the route from the open sea through an intricate maze of small islands and submerged reefs is too shallow for large vessels. Otherwise the site has many advantages including possible use of the nearby airstrip. The nearest large settlement is Faeringehavn, which is twenty miles to the north, so that a separate townsite would need to be constructed. The site is sufficiently far south to increase somewhat the possibility of "storis".

It is apparent from the above brief notes that none of the five "best" sites possesses all the desirable characteristics. To arrange them in order of preference, the relative significance of various factors had to be considered. Good access from the open sea is clearly very important as are reasonably good shelter for the wharf, satisfactory terrain for stockpiling and for buildings, reasonable freedom from fogs, strong winds and other weather hazards. A further advantage is location near an existing large settlement where the working force and their families could live in an organized community.

A party of technical specialists from Canada, Denmark and the United States visited Greenland in August 1956, studied reports prepared by the *Blue Dolphin* party, examined the northerly four sites and recommended that Rype Island appeared to be the best, subject to confirmation that a wide and deep channel links it to the open sea.[20] (Figures 6 and 7)

POLITICAL CONSIDERATIONS

Entirely apart from the task of locating a port-site with suitable physical characteristics, was the equally significant one of reaching an agreement with the Danish and Greenland authorities on use of the site by a private corporation. The Greenland economy has changed drastically during the past twenty years but even to-

day it includes no undertaking operated purely by a private enterprise. The century-old cryolite mine at Ivigtut might be considered as a precedent,[21] but until recent years this mining community was an "enclave", administratively distinct from the rest of Greenland, and in practice isolated from it. Although today the Ivigtut community is no longer politically separate, neither is it a private undertaking since the state owns a majority of its capital. There is a lead-zinc mine at Mestersvig in East Greenland, but this too is in part a crown corporation. Nevertheless despite the lack of any precedent, the Danish authorities were prepared to negotiate an agreement if it could be shown that the transfer port project was advantageous to the new Greenland.

Granting of a "concession" in the ordinary sense was not possible because there is no private title to land in Greenland. Furthermore there is no local tax system through which payment could be made for use of the site, and by which the authorities could be reimbursed for services rendered the company and its employees. Nevertheless in September 1958 a provisional agreement was reached under which a Danish company would be formed to construct and operate an iron ore transfer port, for the account of the Ungava enterprise. The port was to be constructed and manned by Danes and Greenlanders, and a fixed rent, together with a specified royalty per ton of ore handled, was to accrue to the Danish state of which Greenland is an integral part. The agreement was made conditional on the confirmation by Denmark (referred to above) that hydrographic conditions around the portsite and between it and the open sea were satisfactory from a shipping and engineering standpoint.

CONCLUSION

Subject to economic considerations which must take into account among other things the world demand for iron ore in the next few decades, and the relative cost of ore produced in Ungava and that available elsewhere, the port project discussed here is now (late 1959) considered practicable. The essentially simple device by which the limitations of a four month ice-free season in Ungava Bay can be overcome through using a Greenland port, may if successful in this case prove of great significance to other parts of the Canadian Eastern Arctic. The economical production of metallic minerals or oil from Baffin Island and islands farther north depends ultimately on providing inexpensive transportation by sea. It now seems possible that the open seacoast of southwest Greenland may serve as a gateway through which such Canadian minerals may reach the outside world regularly and at a competitive price.

REFERENCES

1. For general location see map: *Canada, Principal Mineral Areas, 1959;* Dept. of Mines and Tech. Surv., Ottawa.
2. See LLOYD, T.: Iron Ore Production at Kirkenes Norway; *Econ. Geog.*, 31, 1955, pp. 211-33, for reference to taconite mining.
3. *Chart 5349, Hopes Advance Bay, Ungava Bay, Scale 1:24,000;* Dept. of Mines and Tech. Surv., Ottawa 1958.
4. Meteorological records have been kept for a few stations in the Ungava Bay region for more than a quarter century, although none are available for Hopes Advance Bay itself. Adjusted monthly and annual mean temperatures for this location and for other stations in northern Quebec for 1941-50 have been calculated by Dr. Martin Rodewald, on the basis of available records, as follows (°F.):

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Hopes Advance Bay	—15	—17	—2	11	28	40	49	46	39	29	14	—1	19
Fort Chimo	—13	—11	3	15	32	44	53	51	42	32	17	0	22
Schefferville	—14	— 9	1	18	34	47	55	51	43	32	16	0	23

The estimated total annual precipitation at Hopes Advance Bay is 17 inches, and at Schefferville 28.3 inches.

5. This table is from Chart 5349 cited in note 3 above.
6. Published data on ice conditions in this area include: *Labrador and Hudson Bay*

Pilot. 1954; Dept. of Mines and Tech. Surv., Ottawa, 1955, particularly pp. 6-8.
DRINNAN, R. H. and L. PRIOR: Physical Characteristics of the Ungava Bay Area; *Geog. Bull.* 7, 1955, pp. 17-37, particularly pp. 32-36.
U.S. Hydrographic Office: *Report of the Ice Observing and Forecasting Program 1957, Technical Report 52;* Washington, D.C. 1958 and corresponding publications for other years.
DANSKE METEOROLOGISKE INSTITUT: *Isforholdene i de Arktiske Have* (The State of the Ice in the Arctic Seas); Copenhagen, Annual.

7. This does not refer to "ice-breakers" such as *d'Iberville*, but freighters strengthened by having closely-spaced frames, heavier plates, etc. as required to meet established insurance specifications.

8. Typical distances between Hopes Advance Bay and overseas ports are as follows:

Hopes Advance Bay to:	
Montreal	1,800
St. John's	1,130
Godthaab (Rype Island)	588
Rotterdam	2,650
Baltimore	2,500
Godthaab (Rype Island) to:	
Rotterdam	2,340
Glasgow	1,850
Baltimore	2,370
Rotterdam to:	
Glasgow	800

9. Alternative charters would be difficult to obtain on an assured, long-term basis. Possible cargoes include ores and oil.

10. See for example, ice-distribution charts on page 103, Tech. Report 52 for 1957. (cited in no. 6 above) On two flights between Nova Scotia and Newfoundland during the last week of February 1957 considerably more ice was observed on the *south* coast of Newfoundland than is recorded on these charts.

11. Also referred to as bay ice, fjord ice, coastal ice, etc. In Danish this is "Vinterisen". Since completion of this paper, additional data of great value have been published by a committee set up by the Ministry for Greenland following the loss of the vessel *Hans Hedtoft* off Cape Farewell in January 1959. Of particular interest are Appendices 29 & 30 dealing with "Ice conditions in Greenland" especially diagrams recording storis limits from 1900-1959. The complete report is *Betaenkning afgivet of Det af Ministeren for Grönland under 19 February 1959 nedsatte Udvalg verdrorende Besejling af Grönland.*

12. For a generalized chart of surface currents in this area see DUNBAR, M. J.: *Eastern Arctic Waters,* Fisheries Research Board of Canada, Ottawa, 1951, Figure 13 on page 48.

13. See RODEWALD, MARTIN: *Klima und wetter der Fischeriegebiete West-und Südgrönland;* Deutscher Wetterdienst, Hamburg, 1955, pp. 9-13. See also DUNBAR: *op. cit.*

14. Ice conditions alone might have permitted choice of a site as far north as Sukkertoppen, but the coast north of Godthaab Fjord is skerry-strewn and hazardous, and a northerly location would add to the shipping distance.

15. An additional climatic factor has to be considered. The stockpile of pellets might become frozen together during winter, due to refreezing rain and melted snow. An analysis by Dr. Martin Rodewald of the "freeze-thaw" frequency for Godthaab suggests that this might be an important factor, needing detailed study. An approximation to the problem may be secured by determining the average number of days in each

MEAN TEMPERATURE °F and PRECIPITATION (inches)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Godthaab: Greenland													
Temperature (°F)	18	18	22	28	37	42	47	45	40	32	25	21	31.25
Precipitation (ins.)	0.6	0.8	0.4	1.0	1.9	1.9	2.3	3.0	2.9	3.2	1.2	0.5	19.7
Kirkenes: Norway													
Temperature (°F)	12	11	18	28	37	47	53	51	44	32	21	14	30.66
Precipitation (ins.)	0.7	0.8	0.6	0.6	0.8	1.5	2.4	1.9	1.9	1.5	1.2	0.8	14.7
Montreal: Canada													
Temperature (°F)	14	15	26	42	56	65	70	67	59	47	33	20	42.8
Precipitation (ins.)	3.8	3.0	3.5	2.6	3.1	3.4	3.7	3.5	3.7	3.4	3.5	3.6	40.8

month when a freeze-thaw occurs. This is done by subtracting the number of days with maximum below 32° from the number with minimum below 32°. The freeze-thaw frequency is smaller within the fjords where a more "continental" climate prevails. The freeze-thaw frequency according to Dr. Rodewald is: July 1, Aug. 1, Sept. 10, Oct. 19, Nov. 11, Dec. 5, Jan. 5, Feb. 5, Mar. 10, Apr. 17, May 22, June 29, Year, 115.

16. RODEWALD: *op. cit.* and *Meteorologisk Aarbog, Part 2, Greenland;* Danish Met. Inst., Charlottenlund, Denmark.
The recent Ministry for Greenland publication referred to in footnote 11 includes, in Appendix 31, a very useful month by month summary of the climate of coastal southwest Greenland.

17. Although this subject is given but scant treatment here, it is in fact a critical aspect of the whole enterprise. For a brief commentary on the socio-economic situation in Greenland today, see LLOYD, TREVOR: Changing Greenland; *The Beaver*, 289, 1959, pp. 41-44.

18. This vessel has carried on research in Labrador waters for a number of years. See for example Dartmouth College Expeditions to Labrador 1951, 2, 3; *Polar Record*, 7, 1954, pp. 144-145.

19. The name in Danish is Rype Ø - meaning "Ptarmigan Island". In Greenlandic it is written Agigssersiorfik.
Climate data for nearby Godthaab and for comparable stations elsewhere are given above. See also data for Hopes Advance Bay, Fort Chimo and Schefferville in footnote no. 4 above.

20. Royal Danish Navy Hydrographic surveyors confirmed this in 1959. A thorough survey of the area between the open sea, the mouth of Godthaab Fjord and south to beyond Rype Island was completed and new charts are being prepared.

21. LLOYD, TREVOR: Ivigtut Cryolite and Modern Greenland; *Can. Geog.*, 3 1953, pp. 39-52.

PRÉSENTATION D'UNE CARTE GÉOMORPHOLOGIQUE DE LA RÉGION DE MOULD BAY, ÎLE DU PRINCE-PATRICK, TERRITOIRES DU NORD-OUEST *

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RÉSUMÉ. *Cette carte, dressée d'après des données recueillies sur place et sur les photographies aériennes, porte sur un territoire d'environ 400 milles carrés, représenté à l'échelle de 1:72,000. Les formations superficielles y ont été figurées par des patrons et les formes du relief par des symboles. On montre dans le texte que la carte géomorphologique est de portée à la fois théorique (géomorphologie pure) et pratique (géomorphologie appliquée: circulation, travaux de génie, etc.) Les méthodes utilisées pour l'établissement de la carte sont également décrites.*

ABSTRACT. *This map, constructed from field data and from information collected from aerial photographs relates to an area of some 400 square miles, represented at the scale of approximately 1 to 72,000. Superficial deposits have been mapped by the use of patterns and landforms by symbols. The text includes a description of the mapping technique and of the potential uses of this type of map for pure as well as for applied geomorphology.*

La carte géomorphologique a pour objet l'étude du relief terrestre. Utilisée conjointement avec la carte géologique et la carte topographique, elle doit apporter une description graphique précise et relativement complète des traits caractéristiques du relief d'une région donnée. Ainsi, la carte géomorphologique décrira tel gradin de terrasse localisé entre deux courbes de niveau de la carte topographique et que celle-ci, par conséquent, ne montre pas. La carte géomorphologique doit, en outre, restituer les formes du relief considérées individuellement ou par familles de formes, du point de vue de leur morphogénèse et de leur évolution morphologique. En plus des formes mêmes du relief, elle doit comprendre aussi certaines données connexes importantes, notamment sur la lithologie et sur la couverture végétale. Ainsi conçue, la carte géomorphologique est susceptible de livrer un enseignement de caractère à la fois théorique et pratique que ni la carte géologique, ni la carte topographique ne peuvent fournir.[1] La carte géomorphologique de la région de Mould Bay que nous présentons ici est, à notre connaissance, la première du genre qui ait encore été établie pour une région du Canada arctique.[2]

MATÉRIAUX DE LA CARTE

La carte géomorphologique de la région de Mould Bay a été levée à partir d'observations effectuées sur le terrain[3] et de l'interprétation des photographies aériennes. Comme fond de carte, nous avons utilisé les feuilles *Prince Patrick Island* et *M'Clure Strait* au 506,880e, desquelles nous avons extrait et agrandi, à l'échelle de 1:72,000 la région de Mould Bay. Les photos aériennes, toutes de l'Aviation Royale du Canada, comportent deux séries de vues. La première série consiste en vues verticales, au 40,000e, ainsi qu'en vues obliques, photographiées le 1er août 1950, donc à une période où la neige était disparue. La seconde série, composée de vues verticales exclusivement, à l'échelle de 1:15,000, a été faite en pleine période de fonte nivale, soit le 20 juin 1950, alors que les parties les plus hautes de la région étaient encore enneigées.

A l'aide de ces matériaux, nous avons pu cartographier à la fois les formations superficielles et les formes du relief de la région de Mould Bay, même pour certains secteurs que nous n'avons pu étudier sur place. Nous avons omis, délibérément, de représenter la couverture végétale à cause de sa très faible influence morphogénétique dans cette région.

FIGURATION DES FORMATIONS SUPERFICIELLES

La carte géomorphologique nous montre la prépondérance du matériel meuble dans le territoire considéré. Les affleurements

* Texte d'une communication présenté au XXVIe Congrès de l'ACFAS, à Ottawa, le 1er novembre 1958, et publié avec la permission du Directeur, Direction de la géographie, Ministère des Mines et des Relevés techniques.

de roche en place, grès et schistes surtout, occupent une très faible partie de la superficie totale cartographiée. Ces affleurements sont essentiellement limités au haut de certains abrupts. Le matériel gélivé grossier de la taille des blocs et des galets se trouve sur les pentes raides localisées en bas des affleurements rocheux et aussi sur certaines surfaces horizontales lorsque la roche en place est près de la surface du sol. Par conséquent, les concentrations de matériel gélivé grossier se présentent le long des abrupts littoraux et à la surface du plateau, les zones basses de la région considérée étant pauvres en concentrations de ce type de matériel.

Nous avons en outre indiqué les sables et les limons au sein desquels on observe des débris grossiers de gélivation non-concentrés. C'est le matériel par excellence des formes de solifluxion. Très répandu dans toute la région, ce matériel provient de la désagrégation en éléments plus ou moins fins du matériel gélivé grossier. Nous avons des exemples de ceci à la surface du plateau où de nombreux îlots de matériel gélivé grossier sont entourés par des sables et des limons.

La région de Mould Bay comprend aussi un type de matériel qui est très répandu. Ce sont des sables du Jurassique qui n'ont été que peu ou pas remaniés par les eaux courantes depuis leur mise en place. Ces sables ne comportent guère de débris gélivés grossiers, même s'ils sont sous-jacents à des bancs de grès. En effet, le grès se débite sur place en éléments fins sur lesquels la solifluxion n'exerce qu'une influence limitée. Ces sables résiduels sont répartis exclusivement dans les secteurs bas, près des rivages.

Nous avons également porté sur la carte les matériaux qui sont actuellement ou qui ont récemment été remaniés par les eaux fluviatiles ou littorales. Les lits fluviaux sont formés par ce matériel plus ou moins arrondi: petits blocs, galets, graviers et sables. Par contre, sauf vis-à-vis l'embouchure des rivières, les estrans sont constitués presque uniquement de sables et de limons en avant des reliefs côtiers bas, et de petits blocs et de graviers en contre-bas des falaises non-fonctionnelles.

La carte montre également les dépôts meubles des formations de Beaufort et d'Eureka Sound. La formation de Beaufort, encore peu connue géologiquement, se caractérise, dans un étage supérieur, par des blocs, des galets et des graviers arrondis ou sub-anguleux, sans litage apparent, ainsi que par des alternances de sables et de graviers lités dans l'étage inférieur. Des billots intraformationnels, non carbonisés et non pétrifiés, probablement d'origine locale, sont typiques de ces dépôts qui ont été mis en place, d'après les analyses effectuées par la méthode du carbone 14, un peu avant le Wisconsin.[4] Les roches de la formation d'Eureka Sound, d'âge crétacé ou tertiaire, sont, elles, des sables et des argiles.[5] Tous ces dépôts meubles, que l'on trouve aussi bien dans les parties les plus hautes de la région que dans certaines parties basses de celle-ci, comme à l'W de la baie Green, ont une morphologie peu variée.

En dernier lieu, on a indiqué les nappes d'eau les plus importantes, lesquelles sont peu nombreuses et qui se rencontrent aussi bien sur le plateau que dans les secteurs bas de la région.

FIGURATION DES FORMES

La délimitation des différents types de matériel ayant été effectuée, nous avons pu cartographier, au moyen de signes conventionnels, les principales formes du relief, soit individuellement, soit en groupes. Une classification génétique des formes apparaît dans la légende: formes d'origine tectonique et structurale, formes fluviatiles et lacustres, formes littorales, formes glaciaires et formes périglaciaires. Certaines généralisations se sont avérées nécessaires, à cet égard, puisque la plupart des formes observées ont eu une morphogénèse composite. Ainsi, nous avons cru utile de grouper dans des catégories distinctes les "formes fluviatiles et lacustres" les formes "littorales" et les "formes périglaciaires" alors qu'en fait toutes ces formes appartienne au même système morphogénétique actuel périglaciaire.

Les formes d'origine tectonique de la carte sont essentiellement des escarpements de ligne de faille. Les formes d'origine

structurale comprennent des escarpements monoclinaux, des collines ou buttes résiduelles et des alignements structuraux. Les collines ou buttes résiduelles ont été représentées par le même symbole, qu'elles aient une carapace gréseuse ou non. Les alignements structuraux sont difficilement repérables au sol, mais ils ressortent bien sur les photos aériennes. Ils se présentent en bandes étroites, sur les hautes surfaces de la région, et sont formés de matériel grossier provenant de la gélifraction des bancs de grès. Nous avons également fait entrer dans cette famille de formes certains abrupts complètement recouverts de matériel grossier de gélivation et dont la genèse est inconnue, faute d'affleurements visibles. Ainsi, les principales caractéristiques structurales et tectoniques de la région apparaissent très nettement sur la carte géomorphologique.

La carte ne montre que les principaux membres du réseau hydrographique, l'échelle utilisée ne permettant pas de représenter le fouillis de petits ruisseaux et d'étangs. Nous avons cependant cru important de bien figurer les ravins fluviatiles, les terrasses fluviales de dépôt, les terrasses fluviales rocheuses, les plaines d'épandage fluviatile, les lits fluviaux à chenaux anastomosés, les cônes de déjections et les deltas. Les données contenues dans ces figurations soulignent, entre autres choses, l'importance des entailles faites dans le plateau par les cours d'eau, celle des épandages fluviatiles localisés à proximité des rivages ainsi que l'énorme développement de certains deltas.

En plus des deltas, d'autres formes témoignent aussi de l'empâtement général du relief des secteurs côtiers de la région de Mould Bay. Ainsi, on n'y trouve pas de falaises vives. De plus, les estrans sont tous en matériel meuble. Leur partie supérieure offre, dans plusieurs secteurs exposés, une topographie heurtée de bosses et de creux attribuables à la poussée des glaces de mer contre le rivage. Par contre, on ne trouve guère trace de formes littorales sub-actuelles dans la région. Les plages soulevées forment pourtant l'un des éléments topographiques les plus importants des secteurs côtiers d'un grand nombre d'îles du district de Franklin. Elles semblent faire totalement défaut dans la région de Mould Bay où les seules traces d'une submersion post-glaciaire récente semblent être un delta non-fonctionnel localisé à l'W de la baie Mould.

Par son climat actuel, la région de Mould Bay appartient au domaine périglaciaire. Les formes liées aux processus périglaciaires, en fait, sont celles qui marquent le plus le relief de cette région, non seulement à cause des facteurs climatiques eux-mêmes mais aussi par suite du caractère extrêmement gélif de certaines roches. Nous avons donc figuré dans le détail les talus et les cônes d'éboulis, les champs de pierres, formes qui sont essentiellement liées à l'action de la gélifraction. Nous avons aussi représenté certaines formes plus complexes: coulées de blocs, coulées de boue, replats de cryoturbation, replats goletz, vallons périglaciaires et niches de nivation. Les formes liées aux actions cryogéniques, comme les fentes en coin et les sols à figure géométrique, ont aussi été portées sur la carte. Leur universalité dans toute la région et dans différents types de matériel démontre éloquemment l'importance qu'y prennent les processus liés au gel-dégel.

Enfin, la carte géomorphologique de Mould Bay indique deux formes glaciaires: des cirques nivo-glaciaires et des stries. La rareté des formes glaciaires s'explique en grande partie par l'estompage dû à des actions périglaciaires particulièrement actives depuis la dernière glaciation.

La carte géomorphologique, on le voit, rend possible l'identification des formes et la description schématique de leur répartition en fonction des matériaux superficiels. Ainsi permet-elle d'arriver à une compréhension rapide et sûre du relief d'une région donnée.

APPLICATIONS PRATIQUES

Mais la carte géomorphologique n'est pas utile qu'à la géomorphologie pure; elle peut aussi rendre de grands services dans le domaine de la géomorphologie appliquée.

Ainsi, l'utilisation de notre carte géomorphologique peut aider à la solution de

certains problèmes de circulation des véhicules-moteur, pendant l'été. En effet, en matériel fin, le mollisol saturé d'eau de fusion de la neige offre une très mauvaise traction. Les bulldozers du poste de météorologie de Mould Bay, machines pourtant puissantes, s'enfonçent souvent jusqu'au niveau du pergélisol sur les pentes sablo-limoneuses qui avoisinent les maisons. D'autre part, en matériel grossier, comme sur les champs de pierres des parties hautes de l'île, les véhicules se butent à des pavages d'éléments anguleux qui rendent les déplacements fort difficiles. En revanche, certains itinéraires naturels sont indiqués par la carte: lits caillouteux de la plupart des cours d'eau en période de basses eaux, terrasses des plaines alluviales, pied de certaines falaises mortes. Les voies d'accès au plateau, en particulier, ressortent nettement.

On connaît les problèmes spéciaux que posent certains sols périglaciaires dans le domaine de la construction des maisons, surtout pour les fondations. A Mould Bay, le matériel sablo-limoneux est extrêmement mal drainé durant l'été. Aussi, les maisons du poste de météorologie sont-elles littéralement enfouies dans la boue, durant cette saison, ce qui rend évidemment les fondations fort instables. La carte géomorphologique peut donc permettre d'entrevoir les principaux éléments naturels des sites et d'éviter de coûteuses erreurs.

L'aménagement de bonnes pistes d'atterrissage est chose particulièrement importante dans des régions comme celle de Mould Bay où l'avion est, avec la radio, le seul moyen de communiquer avec le monde extérieur. Au cours des années qui ont suivi l'établissement du poste, on a utilisé une piste de fortune localisée sur la glace du rivage, à l'embouchure de la rivière. Puis, on a aménagé une piste dans les sables limoneux, au S du cours d'eau. L'un des côtés de la piste coïncide avec la berge du cours d'eau. Par conséquent, cette berge est sapée intensément par le courant fluvial en période de hautes eaux. En outre, le matériel même de la piste se prête au déclenchement d'activités périglaciaires qui provoquent des bosses et des fentes de gel. Pour ces raisons, la piste est en perpétuel état de réparations et les atterissages sont pratiquement irréalisables sans de sérieux risques, durant tout l'été. La carte géomorphologique, encore là, permet d'évaluer certains désavantages naturels de la piste actuelle et les avantages offerts par d'autres emplacements, comme ces terrasses de gravier et de sable localisées au débouché des rivières affluentes de la tête de la baie Mould.

La carte montre également qu'à défaut de piste d'atterrissage utilisable l'été, les lacs ne se prêtent pas plus à l'amérissage d'hydravions. La plupart des lacs sont en effet trop petits. Le seul ayant les dimensions nécessaires est celui qui est situé au NW de la baie. Mais ce lac est couvert d'un champ de glace persistant qu'indique la carte. Les amerrissages ne sont donc réalisables que sur certains secteurs de la baie qui est elle-même engorgée de pack plus ou moins fixé au rivage, durant tout l'été.

Jusqu'à maintenant, aucun navire n'a encore pénétré la baie Mould. Il est cependant à prévoir qu'au cours des prochaines années on essaiera de ravitailler le poste de météo par brise-glace, moyen beaucoup plus économique que l'avion dont on s'est exclusivement servi depuis l'établissement du poste, en 1948. Le problème de l'accès du rivage pour les barges se posera alors. La carte géomorphologique montre que l'endroit le plus propice à l'atterrissage est non pas vis-à-vis le poste, mais à un mille (1,6 km) au NW de celui-ci.

CONCLUSION

Ce que nous venons de dire ne constitue que quelques-uns des enseignements de portée pratique que la carte géomorphologique est susceptible de livrer. Les cartes de ce genre peuvent être, sans aucun doute, un instrument précieux entre les mains de l'ingénieur au stade des avant-projets, en particulier dans les territoires nord-canadiens. Enfin, il apparaît que les géographes auraient tout avantage à rendre la carte géomorphologique partie intégrante de leurs études régionales.

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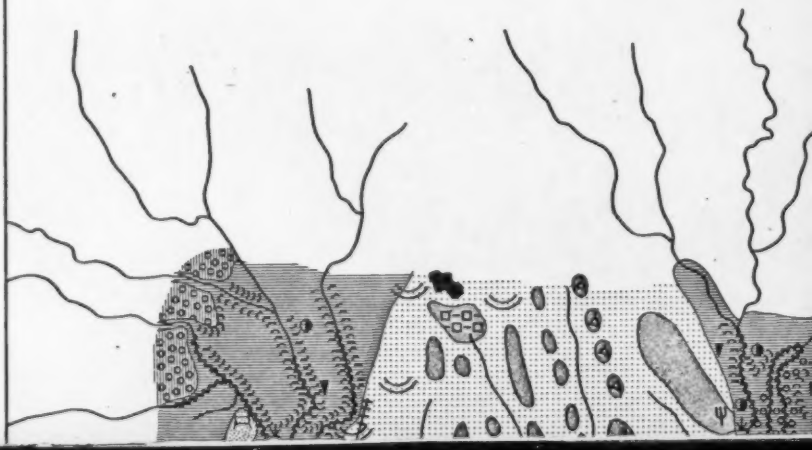

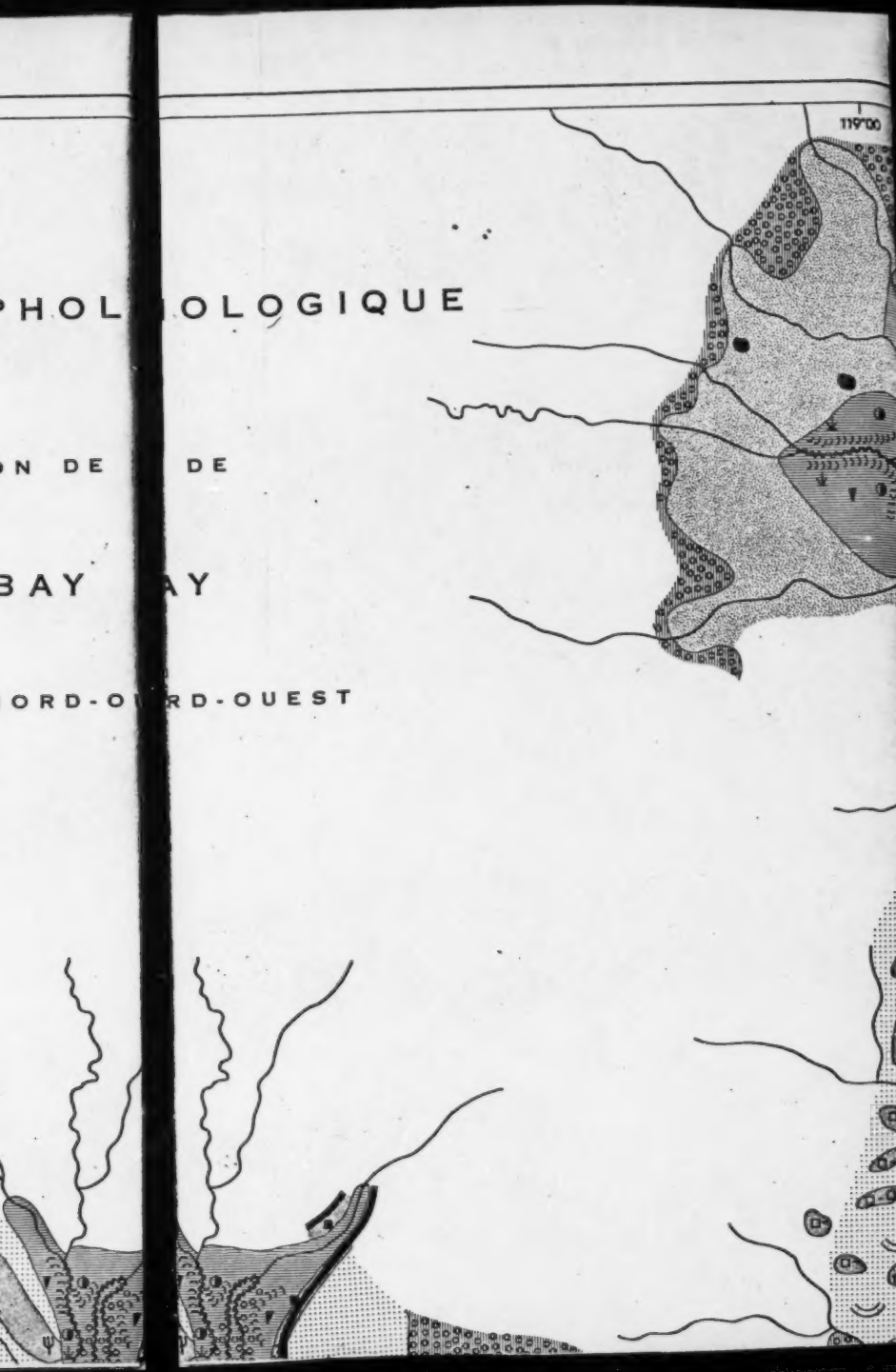
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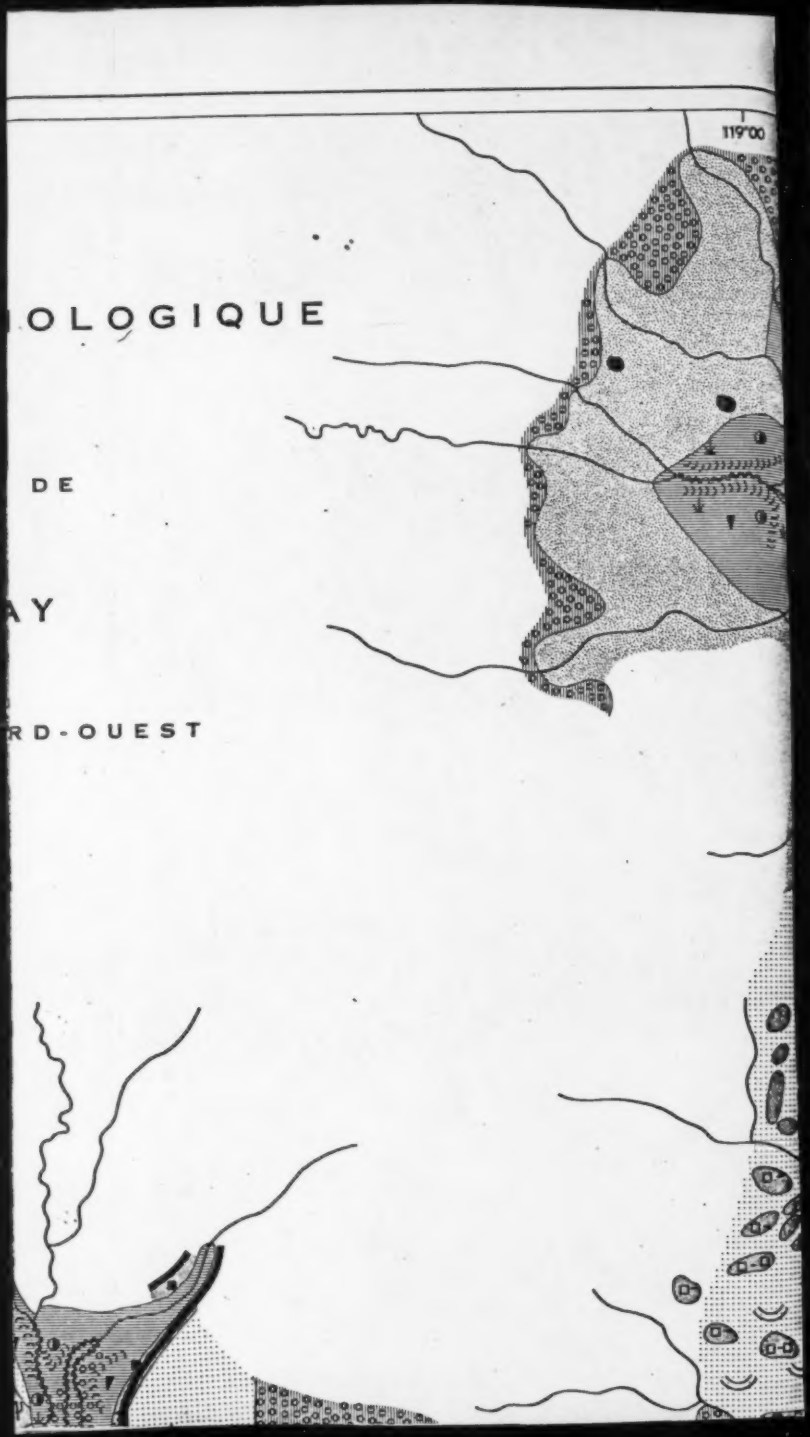
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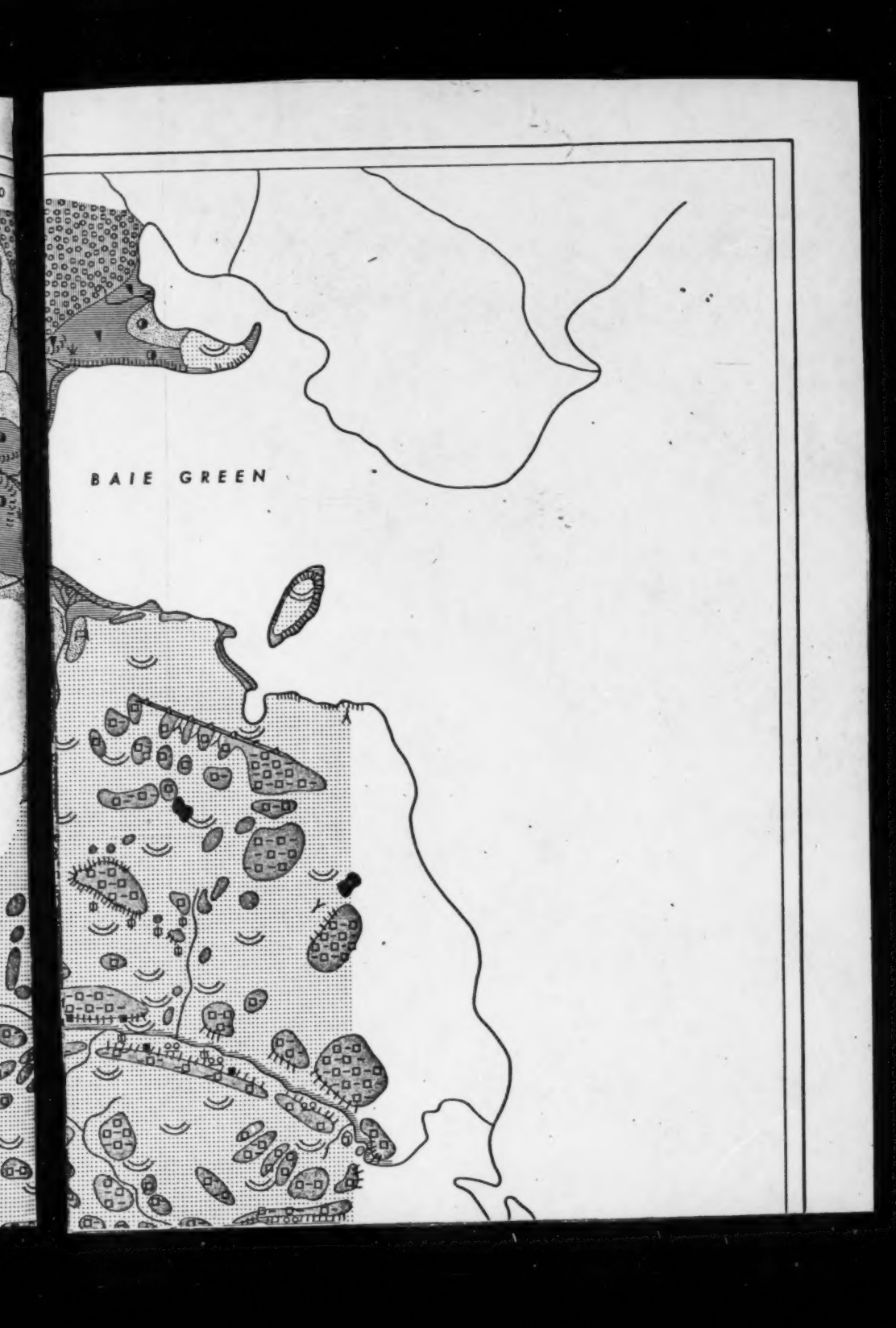
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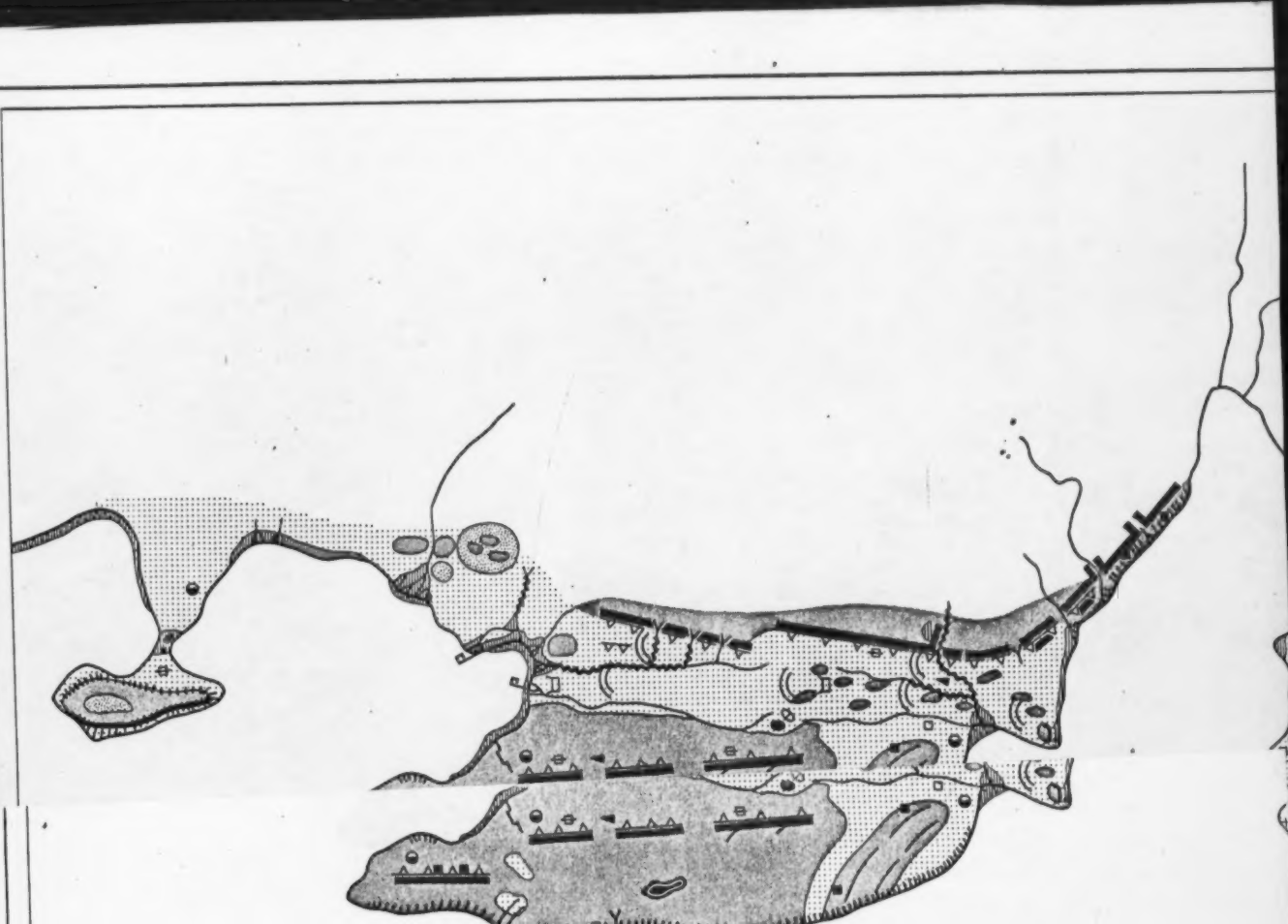

POINTE MANSON

119°00

Roche en place

Blocs et galets gélivés

Sables et limons avec galets gélivés

Sables résiduels

FORMES STRUCTURALES ET TECTONIQUES

Escarpements monoclinaux

Escarpements de faille ou de ligne de faille

Abrupts importants (voir falaises)

Hog's backs

Collines et mamelons résiduels

Alignements structuraux

FORMES LITTORALES

Falaises

Estrans

Flèches et crochets

Plages dérangées par les glaces de mer

FORME ET

Ravins

Terrasses d'

Terrasses roc

Lits à chenau

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Sables et limons avec galets gélivés .....

Sables résiduels .....

FORMES STRUCTURALES ET TECTONIQUES

Escarpements monoclinaux .....

Escarpements de faille ou de ligne de faille .....

Abrupts importants (voir falaises) .....

Hog's backs .....

Collines et mamelons résiduels .....

Alignements structuraux .....

FORMES LITTORALES

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Flèches et crochets .....

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MATÉRIEL

gélivés

s avec galets gélivés

Blocs, galets, graviers, sables et limons remaniés par l'eau

Blocs, graviers et sables de Beaufort ou sables et argiles d'Eureka Sound

Surfaces lacustres

ALES
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FORMES FLUVIATILES ET LACUSTRES

Ravins

Terrasses d'accumulation

Terrasses rocheuses

Lits à chenaux anastomosés

Deltas et cônes de déjections

Deltas fossiles

Plaines d'épandage

Bad lands

Lacs sans champ de glace persistant

Lacs avec champ de glace persistant

Marécages

Cote d'altitude en pieds (approximative)

POSTE MÉTÉOROLOGIQUE

FORMES PÉRIGLACIAIRES

Cônes et talus d'éboulis

Champs de pierres

Coulées de blocs

Vallons périglaciaires

Niches de nivation

Coulées de boue

Replats goletz

Terrassettes

Champs de fentes en coin

Sols polygonaux

FORMES GLACIAIRES

Stries

Cirques nivo-glaciaires

Échelle approximative en milles

2 4 6 8

DIRECTION DE LA GÉOGRAPHIE, MINISTÈRE DES MINES ET DES RELEVÉS TECHNIQUES, 1959

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RÉFÉRENCES

1. Le lecteur voudra bien consulter la carte préliminaire de *Mould Bay*, au 50,000e, publiée par le Service Topographique de l'Armée, Ottawa, 1951, ainsi que la carte géologique en pochette dans TOZER, E. T. : *Geological Reconnaissance, Prince Patrick, Eglinton and Western Melville Islands, Arctic Archipelago, Northwest Territories*; Commission Géologique du Canada, Ministère des Mines et des Relevés techniques, Ottawa, 1956.

2. Le lecteur trouvera à la fin de cette publication, notre carte géomorphologique de la région de Mould Bay.

   D'assez nombreuses cartes géomorphologiques ont déjà été publiées en Europe, notamment en France, en Allemagne, en Pologne et en URSS. Une liste des cartes parues avant 1950 est donnée dans LEFEVRE,M.-A.: Oro-hydrographie, Morphologie - Lithologie; *Atlas de Belgique*, Institut Géographique Militaire, Bruxelles, 1956. Parmi les cartes géomorphologiques les plus récentes, on compte une Carte Morphologique du Bassin Parisien; *C.N.R.S. Mémoires et Documents*, V. 1956; Carte Géomorphologique du Delta du Sénégal, préparée au Laboratoire de l'Institut de Géographie de l'Université de Strasbourg sous la direction de J. TRICART, à paraître dans le *Bulletin Dir. Féd. des Mines et de la Géologie de Dakar*; et Landformen in Mittleren Europa, Morphographische Karte mit Reliefenergie, *Wissenschaftliche Veröffentlichungen*, XV-XVI, 1958.

3. Nous avons travaillé dans la région de Mould Bay d'avril à septembre 1955, en mission morphologique pour le compte de la Direction de la Géographie du Canada. La carte géomorphologique a été préparée lors d'un stage d'étude à l'Institut de Géographie de l'Université de Strasbourg, au titre de boursier du Conseil National des Recherches du Canada.

4. TOZER, *op. cit.*, p. 25-28.

5. THORSTEINSSON, R. et TOZER, E. T. : *Western Queen Elizabeth Islands, District of Franklin, Northwest Territories*; Commission Géologique du Canada, Ministère des Mines et des Relevés techniques, Ottawa, 1959. Voir la carte en pochette.

OBSERVATIONS OF MACKENZIE RIVER DISCHARGE *

W. E. S. HENOCH

Geographical Branch, Ottawa

RÉSUMÉ. *Cette étude résume et analyse les mesures de salinité et de turbidité effectuées lors du voyage du schooner TUHLIK, d'Aklavik à l'île Herschel durant l'été de 1957. On a également étudié, de façon quantitative, le long du littoral de la baie Mackenzie, le processus de mélange des eaux douces du fleuve Mackenzie et des eaux salées de la mer de Beaufort.*

During the summer of 1957 data were secured on the mode and extent of the Mackenzie River discharge. Measurements of salinity and turbidity were taken, and also observations of the factors that influence them such as wind speed and direction, air and water temperature, tides, depths and ice conditions. The purpose of this paper is to describe conditions that govern the mixing of the Mackenzie River waters with those of the Beaufort Sea, and to present the data obtained during the survey.

The Mackenzie River discharges over the continental shelf which, in this area, is 50 to 75 miles wide. The shelf slopes gently to a depth of 33 to 39 fathoms to the break in slope where it becomes very steep and reaches a depth of 2,000 fathoms in Beaufort Sea (Figure 1). The continental shelf has three features in the vicinity of the survey area which give it some relief and undoubtedly influence the currents. The most prominent is the Mackenzie Sea valley, also called Herschel Canyon[1] which extends for about 40 miles in a northwesterly direction east of Herschel Island. Between Herschel Island and Kay Point is a submarine trough which reaches a depth of 40 fathoms and is believed to be of glacial origin.[2] A submarine channel is known to exist in Napoiak Channel estuary.

The schooner *Tuhlik* sailed one to three miles offshore in depths that did not exceed 15 fathoms. The range of the tide did not exceed five inches but it has been observed that with westerly winds the sea level rapidly rose six inches, irrespective of the tide, giving warning of an approaching storm.

Cameron found that "the net circulation in the region is anticlockwise. The low salinity water moves eastward along the coast. Salt water is contributed by a southeasterly flow past Herschel Island, which mixes with river water in Mackenzie Bay".[3] He further states that "the principal oceanographic features of the southeastern Beaufort Sea are established by the interaction of river discharge and wind. In the absence of wind, the river water reacts to the influence of Coriolis' force and hugs the right hand mainland boundary, moving eastward along the coast . . . westerly winds accentuate the magnitude of circulation. Easterly winds of force 5 or greater are sufficient to reverse the circulation. The river water moves offshore to the north and west".

The surface salinity of the oceans varies with latitude. Sverdrup has shown[4] that salinity increases from about 34.5‰ at the equator, to higher salinity, about 35.7‰, in latitudes 20°N and 20°S, and thence decreasing towards higher latitudes. According to Bailey[5] the surface salinity of Beaufort Sea is 4.1‰ to 27‰. This is the result of the freshening effect of the water of the rivers and the polar ice. The influence of the ice is manifold. At the beginning of the break-up the southern limit of the polar pack forms a barrier hindering the northward flow of the Mackenzie discharge. The polar ice pack also restricts the mixing of fresh river water with saline sea water by forming protection from wind-driven currents. On the other hand, the southern limits of the polar ice pack retreat northward under the warming influence of the Mackenzie River waters. The ice pack first withdraws from the eastern part of the coast of the Mackenzie Delta and lingers longest west of Herschel Island. This tendency of the Mackenzie discharge to spread eastward and the subsequent withdrawal of the pack ice from the coast east of the delta might

* Presented at the Eighth Annual Meeting of the Canadian Association of Geographers, Edmonton, 1958, and published with the permission of the Director, Geographical Branch, Department of Mines and Technical Surveys.

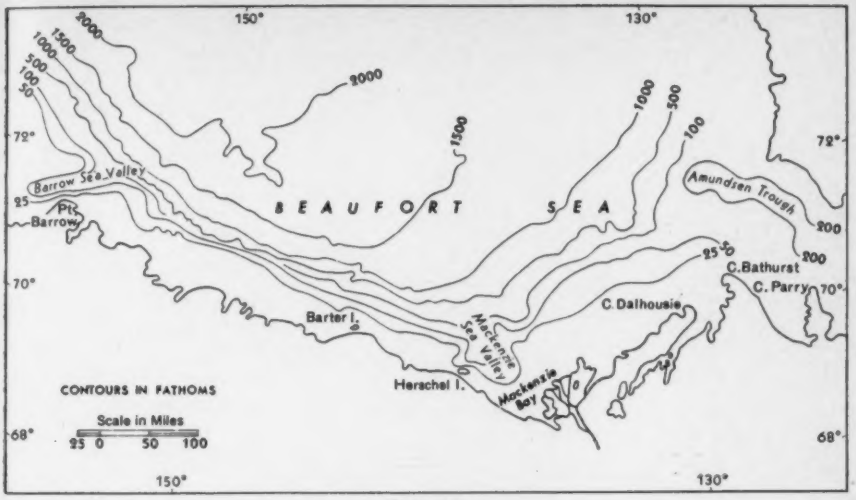

FIGURE 1

be attributed to the effect of Coriolis' force.

From the records of early whalers it is evident that in some years the ice pack did not disappear from the vicinity of Herschel Island, making sailing communication between Point Barrow and the Mackenzie Delta difficult and in some years impossible. Amundsen's[6] voyage was delayed in 1905 for a year by ice conditions. As he sailed westward along the Yukon coast the ice grew gradually thicker until, on September 2, the *Gjoa* was halted at King Point. During the 1957 trip to Herschel Island, the *Tuhlik* followed the withdrawal of the ice pack. On July 6th the ice pack encountered at Sabine Point blocked progress and the *Tuhlik* returned to the harbour at Shingle Point. (Figure 2). King Point was reached eventually on the 9th of June. On the 12th of June, *Tuhlik* was joined by the R.C.M.P. schooner *Aklavik II* at King Point. Both vessels left the harbour at King Point the same morning, but strong seas and the proximity of the ice pack at Kay Point compelled both vessels to return to King Point. On July 14th the sea south of Herschel Island was free of ice and *Aklavik II* was able to reach Herschel Island. Ice floes were observed near Herschel Island until the *Tuhlik* left Herschel on July 27th.

OBSERVATIONS DURING THE TUHLIK SURVEY, 1957 *

During the trip westward to Herschel Island, in the first days of July, fresh water was encountered in the Mackenzie Delta and along the coast to Shingle Point (see Table 1 and Figure 2). The temperature of the water was comparatively high, around 14.5°C.

The first traces of salinity were recorded at Shingle Point where the salinity increased from 0.3‰ on July 4th to 2.5‰ on July 9th. The water temperature was as low as 8.3°C. on July 4th.

* Water samples were taken from depths down to 35 feet by means of a Nansen bottle equipped with a reversible thermometer that gave the temperature of the sample at the depth at which it was taken. The density of the water was measured with a Load Line Hydrometer. Zerbe's[7] tables were used for finding the corresponding salinity. For convenience the readings of the hydrometer are omitted in the attached tables and only the calculated salinity given. Soundings were taken with a Bendix echo sounding apparatus and lead line. Tidal readings were taken from a calibrated rod. Turbidity observations were made with a Secchi disc, which consisted of a yardstick with a white disc of eight inch diameter attached to its end. The depth at which this disc was visible was read from the yardstick. Wind direction was estimated by compass and wind velocity by Beaufort scale.

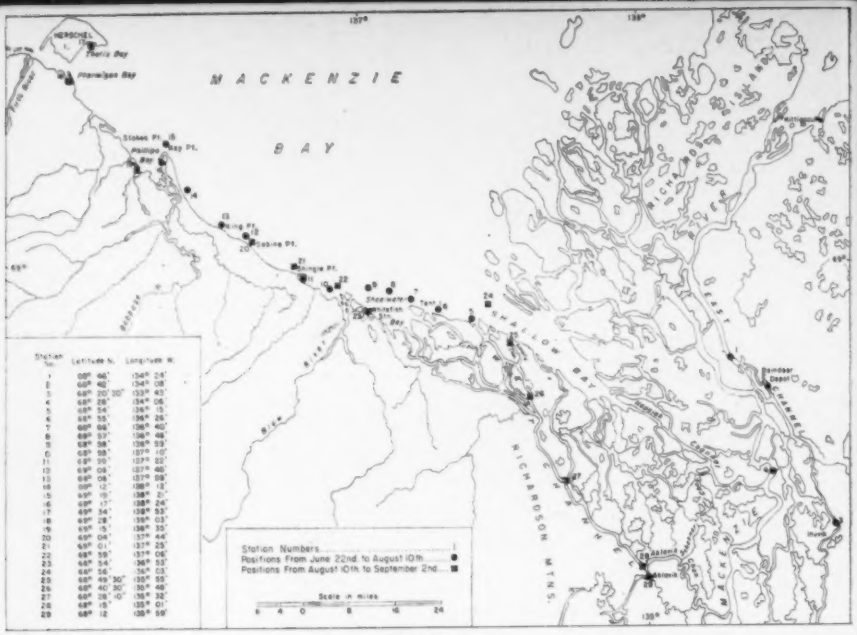

FIGURE 1

TABLE 1

OBSERVATIONS TAKEN BY TUHLIK SURVEY,
JUNE 22 TO SEPTEMBER 2, 1957

STATION	DATE	TIME	DEPTH (FEET)	TURBIDITY INCHES	AIR TEMPERATURE (°C)	WATER TEMPERATURE (°C)	DENSITY REDUCED	SALINITY °/₀₀	TOTAL DEPTH (FEET)	WIND SPEED (MPH)	WIND DIRECTION
1	22/6			8		No	observations				
2	24/6			8½		"	"				
3	26/6			7½		"	"				
4	26/6			7½		"	"				
5	4/7	1330	Surface			15.0	0.9980	0			
6	4/7	1415	"			14.4	0.9989	0			
7	"	1445	"	9x		14.4	0.9989	0			
8	"	1510	"	4x		14.4	0.9989	0			
9	"	1545	"	4x		14.4	0.9989	0			
10	"	1645	"	4x		13.3	0.9988	0			
11	"	1800	"					0.3			
11	6/7	1015	"	4½x		12.8	1.0002	1.3			
12	6/7	1135	"	4½x		14.4	1.0004	1.6			
11	7/7	1845	"	12½		15.0	1.0010	2.4	7½		
11	8/7	1015	"	11	N	11.1	1.0011	2.5	7½	15-25	W
11	9/7	0915	"	12½	11.1	11.1	1.0011	2.5	"	5-10	SW
13	10/7	0830	"	12	11.1	11.1	1.0004	1.6	8	Calm	
13	"	1630	"	8½	15.6	11.1	1.0008	2.1	8	10-15	NNW
13	12/7	0645	"	8	13.3	11.1	1.0006	1.9	8	Calm	
13	13/7	0930	"	7	8.9	12.8	1.0017	3.3	8	0-5	NW
13	14/7	0930	"	7½	12.8	12.2	1.0017	3.3	8	5	NW
13	15/7	0900	"	8	14.8	12.8	1.0037	5.9	8	Calm	
14	15/7	1030	30	0x	8.3	5.6	1.0062	9.2		5	N
14	"	1045	surface	0x	8.3	12.8	1.0037	5.9		5	N
15	"	1150	"	0x	8.3	3.3	1.0208	28.2		Calm	
16	16/7	1045	"	over 36	5.6	10.0	1.0054	8.1		Calm	
17	21/7	1200	"	"	5.6	4.4	1.0100	5.6	8½	10	E
17	22/7	1030	"	"	3.3	3.3	1.0061	9.0	"	10	E
17	23/7	1445	"	"	3.9	5.6	1.0066	9.7	"	5	NE

17	24/7	1230	"	"	5.0	5.0	1.0139	19.2	"	5	NE
17	25/7	900	"	"	7.8	6.7	1.0125	17.2	"	Calm	
17	26/7	1230	"	"	5.0	5.0	1.0161	22.1	"	15	W
17	27/7	015	"	"	5.0	5.0	1.0144	19.9	"	Calm	
18	27/7	1330	"	"	5.6	3.3	1.0235	31.8	9	5	W
18	27/7	2200	"	"	10.6	9.4	1.0167	22.9	"	Calm	
18	28/7	0800	"	"	8.9	8.9	1.0165	22.6	"	5	E
18	4/8	2330	"	"	10.0	10.0	1.0173	23.7	9	5	NE
18	5/8	1030	"	"	12.8	10.6	1.0178	24.3	"	5	E
18	5/8	2200	"	"	9.4	10.6	1.0178	24.3	"	2	NE
18	6/8	0930	"	"	10.0	10.6	1.0168	23.0	"	5	W
18	10/8	0930	"	3	11.7	10.6	1.0158	21.7	"	5	NW
19	10/8	1530	"	24	15.0	15.6	1.0099	14.0	6	Calm	
19	10/8	2010	"	22	11.1	15.0	1.0075	10.8	6	15-20	W
19	10/8	2220	"	22	10.0	13.9	1.0058	8.6	6	Calm	
19	11/8	0845	"	31	8.9	11.1	1.0100	14.1	6	10	W
19	12/8	0845	"	29	8.9	11.1	1.0085	12.2	6	5-10	W
19	13/8	0915	"	29½	7.8	10.6	1.0094	13.3	6	0-5	W
19	13/8	1800	"	23	11.1	11.7	1.0135	18.7	6	0.5	NW
19	14/8	1200	"	14	5.0	10.0	1.0089	12.7	6	10-30	N
19	14/8	2030	"	16	9.4	11.1	1.0080	11.5	6	5	E
19	15/8	0745	"	20	11.1	10.6	1.0050	7.5	6	5	N
13	16/8	0940	"	over 36	16.1	5.7	1.0208	28.2	8	30	W
13	16/8	1600	"	"	20.6	6.1	1.0218	29.5	8	5-20	W
13	16/8	1800	"	"	15.6	9.4	1.0212	27.5	8	5.20	W
13	16/8	1900	sur-face	over 36	15.6	9.4	1.0202	27.5	8	15	N
13	16/8	2145	"	"	13.4	7.8	1.0214	29.0	8	10	NW
13	17/8	0825	"	20	10.0	7.5	1.0204	27.7	8	0-5	W
13	17/8	1215	"	20	10.0	8.1	1.0200	27.2	8	5	N
13	17/8	1315	"	21	10.6	8.6	1.0195	26.5	8	5	N
13	17/8	1515	"	23	10.6	8.6	1.0185	25.2	8	0-5	N
13	17/8	1615	"	20	10.6	8.6	1.0190	25.9	8	Calm	
13	17/8	1730	"	18	10.3	8.6	1.0190	25.9	8	0-5	N
13	17/8	1815	"	18	11.1	8.9	1.0186	25.4	8	0-5	N
13	17/8	1915	"	18	10.8	8.9	1.0191	26.0	8	0-5	N
13	17/8	2020	"	18	11.1	8.9	1.0186	25.4	8	Calm	
13	17/8	2120	"	18	11.1	8.6	1.0186	25.4	8	5	N
13	17/8	2220	"	18	10.0	8.6	1.0190	25.9	8	5	N
13	18/8	0920	"	18	11.7	8.9	1.0191	26.0	8	0-5	E
13	18/8	1030	"	18	11.7	9.4	1.0181	24.7	8	0-5	E
13	18/8	1415	"	18	12.2	9.7	1.0182	24.8	8	5	E
13	18/8	1750	"	18	13.3	9.7	1.0182	24.8	8	5	E
19	18/8	2135	"	18	11.7	10.0	1.0173	23.7	8	10	NW
19	18/8	2230	"	18	11.1	9.7	1.0172	23.5	8	10	NW
19	19/8	Strong	westerly	wind of	20-30	mph	blowing	all	day,	rain	
19	20/8	1330	sur-face	9 over	9.4	8.6	1.0161	22.1	8	Calm	
20	20/8	1530	"	36	9.4	8.3	1.0146	20.1	8	5	N
20	20/8	"	35	"	9.4	7.8	1.0166	22.7	u.k.	5	N
21	20/8	1630	sur-face	"	8.3	10.3	1.0143	19.7	20	5	N
21	20/8	"	20	"	8.3	9.0	1.0171	23.4	20	5	N
22	20/8	1815	sur-face		7.5	9.8	1.0015	3.0	8	5	E
23	21/8	0900	"		6.7	10.0	1.0015	3.0	6	Calm	
23	21/8	1435	"		9.4	10.3	1.0025	4.3	6	5	NW
23	21/8	1635	"		7.8	10.3	1.0015	3.0	6	5	W
23	21/8	2040	"		7.8	10	1.0010	2.4	6	Calm	
23	22/8	1935	"		8.9	10.6	1.0015	3.0	6	5	NW
23	23/8	0645	"		6.7	10.6	1.0005	1.7	6	Calm	
23	23/8	0700	"		6.7	9.4	1.0000	1.1	2	Calm	
23	23/8	0800	"		7.2	9.4	1.0000	1.1	2	Calm	
24	23/8	1235	"		12.2	15.6	1.0002	1.3	6	10	E
25	23/8	1845	"	7½	12.8	15.0	1.0000	1.1	7½	Calm	
25	24/8	0945	"	6	11.7	15.0	1.0010	2.4	7½	5-10	S
25	24/8	1815	"	6	13.9	15.3	1.0005	1.7	7½	Calm	
25	25/8	0915	"	7	10.6	14.2	0.9994	0.3	7½	0-5	NW
25	25/8	2045	"	6½	12.2	14.7	1.0006	1.9	7½	Calm	
25	26/8	0700	"	7	12.2	14.2	1.0009	2.2	7½	Calm	
25	26/8	1830	"	9	15.0	15.0	0.9900	0.0	7½	10	SE
25	26/8	1830	20			15.2	1.0000	1.1	7½	10	SE
25	27/8	0700	sur-face	7½	12.2	14.4	0.9999	0.9	7½	5	NW
26	28/8	1330	"	11½	16.7	15.6	0.9996	0.4	7	Calm	
27	30/8	1745	"	14					18	Calm	
28	1/9	1800	"	11					7	Calm	
29	2/9	1700	"	14					6	Calm	

x Turbidity measured in a pail. Data not comparable.
u.k. Unknown

The salinity and temperature at King Point between July 10th and 15th was similar to that recorded at Shingle Point. The water temperature was close to 12°C. The salinity showed a steady increase to 5.9‰ on July 15th. This tendency to increase in salinity might be attributed to the influence of the prevailing NW wind at this time.

A sample taken from the depth of 30 feet off the base of Kay Point peninsula had a salanity of 9.2‰, while the surface salinity was 5.9‰. With change of wind direction, the salinity of Thetis Bay at Herschel Island may change considerably from day to day; it was recorded as low as 9.0‰ on July 22nd and as high as 22.1‰ on July 26th. The tendency of the salinity to increase continued. High salinity and lower temperatures characterized the water at Thetis Bay, compared with King Point and the presence or absence of ice in the Bay, which never exceeded a cover of 1/10, did not seem to influence the salinity or temperature significantly.

At Ptarmigan Bay between July 27th and August 5th the water temperatures read about 10°C. Salinity was higher than at previous localities, being 21.7‰ to 24.3‰. Cameron[8] found that "the temperature salinity relation of the surface water gives some indication of its origin. Water of low temperature and low salinity is derived from melting ice. Water of high temperature and low salinity is of river origin, while water of high temperature and relatively high salinity represents water which is or has been beyond these two influences for a considerable time". According to this, water in Ptarmigan Bay at the time the observations were made, being of high temperature and relatively high salinity, belongs to the third group. The area was free of ice so the water in Ptarmigan Bay was free of its influence. But it is difficult to account for the lack of influence of river water, especially as the mouth of the Firth River is located only 8 miles to the west and the prevailing winds were from the northwesterly sector. It is likely that the currents coming from this direction are deflected by the small promontory west of Ptarmigan Bay. The sand bar forming the east side of it might effectively protect the Bay from the entry of low salinity water from a southeasterly direction. Wind-driven currents from a northeasterly direction have the greatest chance of bringing water of higher salinity into Ptarmigan Bay.

On the return trip, waters of higher salinity were encountered than on the westward trip. The temperature-salinity relation in Phillips Bay indicates the influence of the discharge of Babbage River. However, the salinity and temperature fluctuated considerably. On August 10th, the salinity recorded was 8.6‰, temperature 13.9°C; on August 13th, salinity was 18.7‰, temperature 11.7°C.; and on August 15th, the salinity dropped to 7.5‰ and the water temperature was 10.6°C.

The change in salinity and temperature at King Point from the first part of July to the second part of August is noteworthy. Between July 10th and 15th the water was almost fresh, from 1.6‰ to a maximum of 5.9‰ with temperature around 12°C., whereas between August 16th and 20th salinity was as high as 29.5‰, and was not observed below 22.1‰ during this period.

The higher salinity in August, in contrast to July, is probably associated with a decrease of fresh water from the Mackenzie and melting sea ice, and the influence of the prevailing northwesterly winds. Our records (Table I) indicated that when the prevailing wind at King Point changed from northwest and west to east, the salinity dropped from 26‰ (temp. 8.9°C.) on August 18th at 0920 hours to 22.1‰ (temp. 8.6°C.) at 1330 hours on August 20th.

The samples taken off Sabine Point indicated that on August 20th this water of higher salinity extended farther east (at least to Sabine Point), with a salinity of 20.1‰ and temperature at 8.3°C. at the surface. A sample taken at the same time at a depth of 35 feet had a temperature of 7.8°C. and salinity 22.7‰, which was 2.6‰ higher than on the surface. A sample from a depth of 20 feet was also taken at Shingle Point on August 20th.

The recorded temperature was 9°C., salinity 23.4‰. On the surface the temperature was 10.3°C., salinity 19.7‰ a difference of 3.7‰.

The temperature salinity relation of surface water at the last two described stations is characteristic of water which for some time has not been strongly influenced by melting ice or river water. In both cases the salinity increased with depth in the manner described above, indicating vertical stability of density distribution.

It is of interest that samples taken at King Point, which indicated strong river water influence, also showed salinity increase of 3.3‰ at the depth of 30 feet. According to Bates[9], Mackenzie River inflow can be classified as hypopycnal inflow with mixing inhibited because of stability between the layers.

At Whitefish Station, where observations were taken near the mouth of a tributary of the Mackenzie River, the salinity between August 21st and 23rd was very low, oscillating between 4.3‰ and 1.1‰. On August 23rd the salinity four miles northeast of the mouth of the West Channel was only 1.3‰ (temp. 15.6°C.).

In the Tiktalik Channel one half mile from its mouth, between August 23 and 27, the salinity fluctuated between 0.9‰ and 2.4‰. On August 28 the salinity at the junction of Anderton and West Channels, 15 miles south of the mouth of Tiktalik Channel, was 0.4‰. A sample taken in Tiktalik Channel on August 26 at a depth of 20 feet had salinity at 1.1‰, temperature 15.2°C. It would be of interest to find traces of salinity so far south in the delta. Unfortunately these low readings may be due to instrumental errors, so no conclusion can be drawn till the salinity in the delta is tested by more accurate methods.

As far as turbidity is concerned, our observations suggest that in early July at Shingle Point and King Point the water had much the same amount of sediment in suspension as in the channels of the delta.

In comparing the turbidity in July and August along the coast, a sharp decrease in August is noted indicating the decline in the amount of sediments in the Mackenzie River water. The same is true of the main channels of the delta. The turbidity recordings at Aklavik at the end of June fluctuated between 5½ inches and 8½ inches. In early September the turbidity was recorded in Aklavik Channel as 11 inches and in Peel Channel as 14 inches. These measurements may indicate that the turbidity in the Mackenzie Delta declines during the summer in general, but it has been observed that a heavy rain increases it considerably.

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SHORTER COMMUNICATIONS — BRÈVES COMMUNICATIONS

THE PALLISER EXPEDITION AND WESTERN CANADA*

The extensive and significant work of this scientific exploring party has been obscured by its unfortunate association with the concept of "Palliser's Triangle". The expedition, originating through the efforts of the Royal Geographical Society spent the years 1857-59 exploring and carrying out pioneering scientific observations on the prairie plains and in the southeastern cordilleran region.

The reports and maps produced by the expedition made available for the first time reliable information concerning the character of much of the western part of British North America. Bourgeau gathered extensive botanical collections and Dr. Hector made pioneer contributions on the geology of the areas traversed. The southern portion of the Rocky Mountains was explored, many of the passes were examined, and scores of place names were selected. Basic contributions in geographical and other scientific knowledge concerning the west were made. The vegetation zones of the plains were identified and the three prairie steppes or levels were named and mapped. On the basis of the then current agricultural practices and technology, Palliser and his associates considered much of the short grass prairie too arid for agriculture but were optimistic about the encircling fertile zone which they identified. Palliser could not foresee the construction of a railway through the mountain passes which the expedition had found nor would he recommend a line north of the Great Lakes. He did, however, feel that a new colony, extending from Red River to the Rockies, should be organized.

Palliser's pessimistic outlook regarding settlement was most strongly challenged two decades later by the botanist John Macoun who rejected the idea that aridity would be a hindrance to agriculture. If Palliser misjudged the agricultural possibilities of the southern prairies, his conclusions should have served as a warning against unplanned and overly ambitious settlement.

Ralph D. VICERO

THE FUTURE DEVELOPMENT OF DEEP SEA ORIENTED INDUSTRIAL LAND IN THE BRITISH COLUMBIA LOWER MAINLAND REGION WITH PARTICULAR REFERENCE TO SQUAMISH*

The potentiality of Squamish as a location for major deep sea oriented industries is particularly interesting due to its comparative isolation from Vancouver, the center of industrialization in the Lower Mainland Region.

Choice deep sea industrial land in and adjacent to Vancouver has been committed to use in large quantities since the end of World War II. The prospects for further industrialization of British Columbia are highly favourable. Concern is being expressed over the ability of additional industries to find suitable sites in areas accessible from the sea. Consequently, attention has been focused on Squamish and other areas, which are closer to Vancouver, as sites for major tidal land reclamation projects.

Squamish does not have direct access to transcontinental railways, gas and oil pipelines and other services and amenties associated with an urban area. On the other hand, it offers advantages to industries having extraordinary site location requirements. Intensive industrial development there will depend on the value of its particular attributes to specific industries and on the manner in which deep sea industrial land requirements are satisfied in areas closer to Vancouver.

It is concluded that a major tidal land reclamation project may be undertaken near Vancouver in the next decade. Existing waterfront industrial areas will become more intensely utilized. Squamish will be attractive to particular industries but most deep sea oriented industries will prefer to locate elsewhere unless unusual circumstances prevail.

Jack K. STATHERS

* Abstract of a paper presented at the Ninth Annual Meeting of the Canadian Association of Geographers, Saskatoon, 1959.

TERMES UTILES DANS LA DESCRIPTION DES GLACES FLOTTANTES*

Bien qu'au cours du 19ème siècle, un essai de vocabulaire glacial français-anglais eût paru, ce n'est que depuis une dizaine d'années que les ouvrages sur ce sujet commencèrent a se multiplier. On possède maintenant, une bibliographie d'environ cent titres traitant du même sujet.

La nécessité de s'exprimer adéquatement et l'inexistence d'un glossaire français approprié ont légitime la parution de cette étude terminologique.

Quatre groupes de mots furent relevés: d'abord les termes populaires en "français de France", tel glaçons; les expressions franco-canadiennes, tel glaces vertes; de plus, les termes scientifiques peu connus mais déjà publiés, tel déglacement; et finalement certains néologistes suggérés comme cycle glacial.

Parmi les divers types de glace étudiés on note les glaces de mer, les glaces d'estuaire, les glaces de rivières de même que les glaces de lacs. Les termes se rapportent avant tout aux glaces proprement dites et à l'influence qu'elles peuvent avoir sur la morphologie, sur l'hydrologie, sur la navigation et l'habitat.

Tout compte fait, ce dictionnaire glacial contenant environ 150 termes et synonymes français constitue une contribution importante au périglaciaire canadien.

Louis-Edmond HAMELIN

* Résumé d'une communication présentée à la neuvième réunion annuelle de l'Association Canadienne des Géographes, Saskatoon, 1959.

A STUDY OF PITTSBURG TOWNSHIP*

Pittsburg Township lies on the eastern edge of the City of Kingston. This eastern Ontario city, now of nearly 50,000 population, has grown constantly since 1940 and accompanying this growth there has been considerable suburban and industrial development in areas some considerable distance beyond the city. But no such developments have occurred in Pittsburg despite a number of seeming advantages possessed by this municipality. Despite adjacency to the downtown and industrial sections of the city, Pittsburg remains a rural township in which about eighty per cent of the area was classed as occupied farmland in 1956.

Two general problems emerge when the characteristics of the township are considered. The first concerns the continued existence of its rural character; the second lies in the definition of those internal factors that have contributed to the land use pattern. An examination of these problems should help in forecasting the future of the township and may assist in bringing about a re-appraisal of the role of physical barriers in affecting land use in other areas.

The effects of the physical barrier, in its varied forms, upon land use probably are most apparent in rural areas and on regional scales but barriers have been significant, too, in influencing the discrete spread of the urban area. In Pittsburg, the role of the barrier has been particularly effective and, in considerable measure, the special status of the township is attributable to that role.

J. Howard Richard

FORMER TRANSHUMANCE IN THE SCOTTISH HIGHLANDS*

The basis of the transhumant mode of life in the Scottish Highlands was the "shealling" system, a method and pattern of pastoral farming hitherto ignored by geographers in Britain.

The areas chosen to illustrate lie in the Central Highlands where 3500-foot relief, a marked vertical zonation of vegetation, and an adverse winter impose a seasonal pattern on any grazing programme. There were at least two altitude levels at which shealling villages were sited, some of the wintertown villages possessing more than one shealling at each level. Each wintertown and its grazings lay within well-defined boundaries. The migrations were complex. The stock was divided into two main herds : one for milk-cows, another a mixed herd of sheep, young cattle, and ponies. The grazings were each divided to permit rotational grazing, and unoccupied grazings were patrolled to keep off stray cattle.

Often when the traditional transhumance came into conflict with the ideas of the Agricultural Revolution, new adaptations of the system were introduced.

Conclusions are (a) that the shealling system was an intensive method of hill land-use, based on a folk-lore of nutrient and medicinal plants; (b) that its replacement by extensive sheep farming resulted in deterioration of the pastures to the present; (c) that its ecological position should suggest lessons for North American mountain grazing practices; and (d) that other Old World transhumant grazing systems might be re-examined with profit from this point of view.

Alan G. MacPherson

COMMUNITY PLANNING AND GEOGRAPHY*

The purpose of the paper is to illustrate the contribution the geographer can make to the planning field. It indicates the role of the geographer who is trained to carry out surveys, interpret land use maps, and statistical data on a regional basis.

It is the job of the planner to interpret the material that the geographer has prepared and to recommend the appropriate action necessary. He systematically tries to anticipate and achieve adjustments to the physical environment consistent with social and economic trends.

As a specific example of this close relationship, the paper expands on the land use map which is a basic tool for both the geographer and the planner. Land use maps indicate to the planner relationships between land uses, competition between land uses, expansion of the urban uses, the relationship between traffic and adjacent land uses, trends in land use, and indicate the major function that the urban centre plays. With the knowledge gained from the land use map and other supporting data the planner is assisted in the drafting of zoning by-laws and the preparation of plans for future development.

M. H. Sinclair and W. E. Thomson

* Abstract of a paper presented at the Ninth Annual Meeting of the Canadian Association of Geographers, Saskatoon, 1959.

* Abstract of a paper presented at the Ninth Annual Meeting of the Canadian Association of Geographers, Saskatoon, 1959.

THE MINING REGIONS OF LABRADOR-UNGAVA.*

Of the six mining regions that can be distinguished in Labrador-Ungava, two already contain mines in production, mining is to begin in a third in 1961, and plans for production from a fourth are expected to be announced in the near future.

A study of the regions suggests that they can be arranged in an evolutionary hierarchy according to the stage of development reached. Unfortunately the number of examples involved is too small to prove that the conclusions have general applicability, but it is thought that with further work a valid genetic classification may be evolved. In addition, the regions exhibit certain features which are common to most contemporary mining developments, and illustrate the problems which face the industry beyond the pioneer frontier.

For the Human Geographer the Knob Lake and Montferre regions are particularly interesting. The former already has a predominantly French-speaking population, and deliberate policy will be pursued to produce the same result in the latter. Thus the French Canadians only 'homeland' is being extended, at the same time as Canada's effective national territory.

Graham HUMPHRYS

COMMENTS ON L'INFLUENCE DU RELÈVEMENT POST-GLACIAIRE SUR LE RÉSEAU HYDROGRAPHIQUE DE LA VALLÉE DU SAINT-LAURENT".*

The whole problem of the post-glacial evolution of the drainage of the St. Lawrence valley is one of great interest and complexity, and many factors have been involved. M. Ritchot has confined his attention to one of these factors, post-glacial uplift.

He notes the asymmetry of the drainage pattern, with the St. Lawrence river flowing north of the axis of the valley, the strongly developed south-facing bluffs marking former water levels, and the tendency for past and present braided streams to abandon their more southerly channels in favour of those to the north, even when, as in the case of the St. Lawrence near Montreal, the northerly channel, unlike the southerly, lies across bedrock.

M. Ritchot suggests that these features result from the asymmetry of the alluvial floor of the valley, which slopes down toward the Laurentians. The drainage has consequently tended to migrate downslope, toward the north. He attributes the transverse slope of the valley floor to unequal isostatic depression beneath the ice-sheet. The thickness of ice, and consequently the depresison, were greater to the north. He concludes that isostatic equilibrium accounts for all the features of the drainage pattern which he has noted.

This argument has a number of weaknesses. No evidence is offered to support the assumption that the transverse slope of the valley floor in fact results from differential depression beneath the ice-load. More important, however, is the omission of any mention of post-glacial isostatic readjustment.

More than twenty years ago, Chapman demonstarted that in the Champlain valley, the shoreline which he attributed to the Champlain Sea had been differentially uplifted, so that it now rises northward. (CHAPMAN, D. H.: Late-glacial and post-glacial history of the Champlain valley, *Amer. J. Sci.*, 234, 1937, pp. 89-124.) It is not unreasonable to suppose that similar differential uplift occurred in the adjacent St. Lawrence valley during the retreat of the Champlain Sea. There is, in fact, supporting evidence for this view in the lower Ottawa valley near Lachute, where the more northerly of a series of parallel channels appear to have been abandoned in succession. As M. Ritchot's stated object is to examine the influence of post-glacial uplift upon the drainage pattern, his failure to make any mention of its probable differential nature, even in a brief résumé, is unfortunate.

Joyce C. BROWN

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* Abstract of a paper presented at the Ninth Annual Meeting of the Canadian Asosciation of Geographer Association of Geographers, Saskatoon, 1959.

* See Ritchot, Gilels : L'Iinfluence du relèvement post-glaciare sur le réseau hydrographique de la vallée du Saint-Laurent; *Le Géographe Canadien*, 14, 1959, p. 44.

NEW PUBLICATIONS — NOUVELLES PUBLICATIONS

GENERAL GEOGRAPHY by J. Wreford Watson. 552 pp.; maps, photos. The Copp Clark Publising Co. Ltd., Toronto, 1957. $ 8.00.

This is another milestone in the development of geography in Canada if only for the fact that it is the first general geography written in Canada by a Canadian for high school or beginning college students. But this would not be worthy of comment if this was just another "introductory text". That this is not so is evident by a glance at the table of contents. It lists all the familiar ingredients of such books — space relations, the physical factors of the environment, man in the principal climatic regions of the world and the elements of economic and human geography — but the emphasis is peculiarly Canadian. Of the 29 chapters, no less than eleven are devoted exclusively to physical geography while, at the other end of the scale, four are concerned with urban geography. This, in itself, is an interesting response, by a geographer, to the land of Canada, in which 58 per cent of the people live in cities, towns and villages and in which more than 3,000,000 square miles remain virtually uninhabited.

Although the book is concerned with world geography, Canadian readers will undoubtedly be arrested by the fact that as "few of the books about the subject have provided Canadian examples in connection with the topics or regions discussed, the present work tries to remedy this situation by describing the elements of geography mainly in terms of the Canadian landscape, wherever this is appropriate. This is most obviously evident in the photographs and, as a result, the Canadian pictures alone could form a collection of great value in the teaching of the geography of this country. Of special use are the juxtapositions of portions of topographical maps and vertical air photographs in the chapters on the Structure of the continents; the Landscape and the river and Wave, wind and ice. These examples must have been most painstakingly selected from the National Air Photograph Library of R.C.A.F. prints and it is unfortunate that the publishers did not use a better type of paper on which to reproduce them. Many are so badly printed that they lose most of their value.

As far as numbers of photographs and diagrams are concerned, the book is lavishly illustrated for of the total of 552 pages, fewer than 150 are of uninterrupted text. Some of the photographs, such as those of Cornwallis Island (p. 111) and the ice wedge at Brock delta (p. 243) were taken by members of the Geographical Branch, Department of Mines and Technical Surveys, but there are multitudinous pictures credited to the Geological Survey of Canada of the same Department and to the National Film Board. These alone should indicate to the student the wealth of raw material which exists in Federal Government departments and agencies if one takes the time and trouble to seek it out.

The marks of the author's years with the Geographical Branch are also evident in the diagrams and maps. The map entitled "The Arctic in World Airways" is taken from a Branch publication; the material on arctic soils on p. 255 and on Montreal on pp. 385 and 503 are based on work done in the Branch by R.T. Gajda and P. Camu while the fisheries map on p. 366 and the figure entitled "Comparison of Scales" on p. 32 both bear resemblances to the premilinary work on these sheets of the *Atlas of Canada*. Indeed many of the maps and diagrams were drawn for *General Geography* by Anna Marie Kroger, who was an employee of the Branch and Hania Guzewska, who is still with the Branch.

There are also, of course, many evidences of the author's own detailed research, particularly in the chapters on urban geography, and Ottawa and Hamilton loom large in the illustrative examples. The influence of Griffith Taylor is also apparent in this section, but the philosophy is particularly that of the author, especially on "social geography" — a field in which, in many ways, he was a pioneeer. (The term as such, however, is hardly used — one suspects in deference to the publisher's wishes).

In reading the book, this reviewer, at least, was struck by the mixture — *almost* a blend — of British and American approaches to geography. It is unlikely that an American would have used the title *General Geography*, for instance, while British geographers would be loth to use the Köppen climatic classification, or such terms as *ergograph* or *hobohemia*. In fact the book reflects so much of the thinking and practice of the "Toronto school" and the profession in Canada over the past decade or so, that in many ways it is an image of our collective development. To have the image in such clear focus is welcome, and encouraging !

N. L. NICHOLSON

LAB MANUAL IN PHYSICAL GEOGRAPHY by A. H. Laycock and R. Common. 70 pp. The University of Alberta, Edmonton, 1959.

A physical geography laboratory manual implies a physical geography laboratory. What does one expect to find there ? Professors Laycock and Common draw attention to this question in publishing a ring-bound book of sheets of questions and working material, for a one-year practical course at university level.

Designed for weekly 'lab' meetings of two hours, the subjects treated are divided into four groups. The ten meetings given to 'topographic map interpretation' involve the answering of, to some extent repetitive, questions on the landforms, characteristic features, potential land use and so on, represented in about 40 map sheets. The latter (which of course, have to be obtained in addition) show a selected range of landscapes and map types. Seven meetings are taken up with interpretation of weather and climatic data,

including the plotting of figures and drawing of maps, together with discussion of causes. 'Vegetation, soil, water and minerals' involves a Correlative approach, with further study of map sheets and atlases. Minerals are dealt with largely from their relationship to human geographical factors. Two meetings for 'intergration and evaluation', in spite of the title, apparently ask for broad conclusions from rather little material.

There is a detailed list of the maps cited, with remarks on the landscapes they show, additional extracts from Canadian weather records, a list of references, and supplementary notes. Some unfortunate errors appear (e.g. 'average daily temperature' for 'average hourly temperature', the frequent ommission of units : 'ins.', '°F', — but not in 'Lat. 50°F' !).

Personal views, as the authors say, will influence the amount and nature of detail offered in such a course. Their own views as revealed in the manual, should provoke discussion. References, for example, to air and ground photographs, specialised maps, soil and rock samples, are scant or absent. With a closer attention to these and other 'source materials', the limitations and significance of generalisation might be more fully appreciated. However, detail ought not to mean dull repetition. If a student cannot grasp the concept of scale, will the hour or two's arithmetic which occupies half the first 'lab', help him ? It is hardly stimulating for brighter individuals.

The laboratory manual can also be used in part, or supplemented; the contents do not have a marked local (Alberta) bias. Instructors may be interested in gaining ideas from it, and in using the selected map examples. Following the course rather rigidly, they will only require a quite ordinary classroom with big tables (and the maps).

P. J. WILLIAMS

MÉLANGES GÉOGRAPHIQUES CANADIENS OFFERTS À RAOUL BLANCHARD. 500 pp.; maps, photos. Les Presses Universitaires Laval, Québec, 1959. $7.50.

There are no grand old men within the ranks of Canadian geographers, although we may safely assume that the passage of time will produce them. Several men of such stature have been in our midst in Canada, however, and this volume of essays pays tribute to one of them: Raoul Blanchard, longtime Professor of Geography at Grenoble, Visiting Professor at the universities of Montreal and Laval, geographical authority on the Alps and French Canada, and renowned member of a passing species, "the complete geographer." The formidable task of organizing the volume, and carrying it through from idea to reality, was taken on by the young Institut de Géographie of Laval University. English speaking geographers in Canada are invited to read these thirty-eight essays, for to quote the editor, Louis-Edmond Hamelin, "les M.C.R.B. deviennent ainsi, en même temps qu'un livre d'hommage à un maître, une occasion de choix de diffuser, au Canada, la pensée géographique d'expression française." (p. 8)

All but seven of the thirty-eight essays of this volume are written in French. This reviewer cannot refrain from mentioning the advantages of the language over English for expressions of sentiment. There is deep personal affection for Raoul Blanchard in these essays, sincerely and openly displayed; somehow it would not sound as well in English. The contributors can be classified as (1) French geographers who have been visiting professors at Quebec universities, (2) French Canadian geographers who have studied in France, (3) French Canadian geographers who are contributing to our knowledge of Quebec, (4) English speaking geographers, and finally, (5) non-geographers who are enriching our discipline by their research in allied fields. To this reviewer, there are too many contributors varied in outlook and competence to produce a work with soundness in all its parts. The same target could have been brought down by fewer guns, for a few blank cartridges have been fired. Sheer quantity is a drawback to this collection of essays.

The reader is cautioned at the outset on the handling of this volume; to read it in its entirety over a matter of a week or so results in confusion over the nature of geography. Sample it slowly, and enjoy the quality of individual essays rather than deplore the uneveness of the whole.

Where is the quality to be found ? French geography has a long tradition of association with history, a fact worthy of note. Michel Phlipponeau (université de Rennes) and Pierre Flatrès (université de Lille) are worthy carriers of this tradition. Professor Phlipponneau provides us with an insight into the geography of New France in the late seventeenth century in his article, "Le Maréchal de Vauban, un ancêtre de la géographie appliquée au Canada." Professor Flatrès undertakes to unravel and hold up to examination the emigration of folk from Britanny to Canada in an interesting essay entitled, "Bretagne et Canada: quelques aspects de l'émigration bretonne au Canada." Geographers are apt to leave the history of exploration to the historians, and Professor Trudel (Université Laval) does a creditable job on the topic "L'Europe en quête de l'Asie, 1492-1524."

Physical geography is not the "tour de force" of this volume. François Taillefer (université de Toulouse) makes the point in his essay that geomorphology is always subordinated to geography by Raoul Blanchard. Times change and the new questions require a new methodology. The reviewer believes that geomorphologists of today must have the freedom to examine process without the necessity of relating their work at all points to the general field of geography. The intended implication is that geomorphology is moving towards recognition as a separate discipline, with independence day coming before the end of the twentieth century. Such a prospect, if it exists, runs counter to French traditions in our discipline. Possibly it explains the wide

gulf between "Observations sur quelques Lacs Ronds Nord-Américains" by André Cailleux (Sorbonne) consisting chiefly of descriptions of round lakes and ponds seen on several commercial flights across North America, and the more detailed geomorphological studies familiar to us.

Quantity and some quality are to be found in the works on economic geography. It becomes apparent that more research has been done in this field in Quebec than in any other province. Here is testimony to the inspiration and leadership of Raoul Blanchard. The opportunity appears to exist for a French Canadian geographer to study of Quebec based upon current research.

Professor Hamelin deserves much credit for the editing of this volume. Thirty-eight authors will always bring problems for the editor to solve. The unsolved ones remain to weaken the finished product, and to invite critical comment. Eighty percent of the contributors followed the invitation of the editor to write on a Canadian theme. The appearance in this volume of the remaining twenty per cent is rather unfortunate, notwithstanding the quality of the essays by Baulig, Mackay, Gottman, Despois, and Deffontaines. The editorial decision to limit the papers to a common theme would have been difficult to make, but it was necessary, and it should have been made.

The editor makes the claim for cartographical excellence, and I quote, "la qualité et l'abondance des illustrations situent les M.C.R.B. à un niveau exceptionnel." (p. 10). To this reviewer, the adjective "exceptional" more properly qualifies the necessary acuity of vision for the reading of no less than sixteen maps without the aid of a magnifying glass. The base map of Canada used by Professor Garry and reduced to a scale of five hundred miles to the inch is the chief offender, and the base map employed by Professor Brouillette is open to the same criticism. On the other hand, the use of numerous photographs of excellent quality is commendable.

There are some irritating errors, admittedly few in number, that could have been eliminated by more careful editing. The essay by G. O. Villeneuve on the climate of Quebec employs a concept of continentality that is introduced in a confusing manner in the text, and the only bibliographical reference given is too lacking in detail to be of any assistance. The total absence of maps to illustrate this article taxes the reader unduly.

The editor is always vulnerable in an undertaking of this scope. Criticism is perhaps too easy, and the reviewer wants to make it subordinate to high praise for a worthwhile undertaking by our French colleagues. There are many articles that will be turned to with profit by geographers; to this reviewer, in addition to the authors singled our for earlier comment, Barbeau, Hare, Dagenais, Falaise, Lloyd, and Garry stand high on the list of contributors. "Mélanges Géographiques Canadiens offerts à Raoul Blanchard" deserves recognition as an important publication in Canadian Geography.

Gordon MERRILL

PERSPECTIVE ON THE NATURE OF GEOGRAPHY by Richard Hartshorne. 201 pp. Rand McNally & Co., Chicago, 1959. $5.00.

"To include in a single field the great variety of incommensureable phenomena that form the total complex, there must be some principle of selection. This principle is provided in geography by its concern from its earliest beginnings with the earth as the home of man. The measurement of relative importance among the unlimited variety of phenomena presented in the earth surface is determined in geography by their significance, actual or potential, direct or indirect, to man." The thought of this statement combined with the classification of geography as one of the chorological sciences, leads Dr. Hartshorne to a definition of geography as "The study that seeks to provide scientific description of the earth as the world of man". *Perspective on the Nature of Geography* is not merely an elucidation and justification of this definition, it is primarly a series of learned discussions of major conceptual and methodological problems from which the final definition is abstracted.

The organization of the book is based on the proposition that the nature of geography should be induced from opinions on the nature of geography as expressed by leading authors; it seeks "to determine the actual character of geographic work as geographers have viewed that work". Deduction from *a priori* theories of the nature of geography is specifically avoided. The inductive approach is organized under ten major conceptual and methodological problems that have accumulated throughout the history of geography, each of which is the subject of a chapter. The problems, as indicated by their chapter titles are as follows : What is Meant by Geography as the Study of Areal Differentiation ?; What is Meant by the "Earth Surface"? Is the Integration of Heterogeneous Phenomena a Peculiarity of Geography ?; Must We Distinguish Between Human and National Factors ?; The Division of Geography by Topical Fields — The Dualism of Physical and Human Geography; Time and Genesis in Geography; Is Geography Subdivided Between "Systematic" and "Regional" Geography?; Does Geography Seek to Formulate Scientific Laws or to Describe Individual Cases ?; The Place of Geography in a Classification of the Sciences.

The concepts under which the problems are grouped (expressed as chapter titles) might be called 'syndromes' of problems, which to a considerable degree make each chapter disparate, with no easy transition between one and other. This is of course an aspect of the inductive approach in which the existence of the problems is first observed, the problems themselves being subsequently grouped under concepts between which there is no necessary progression of thought. The chapters are, to a degree, knit together by their contibutions of refinements to an initial definition of geography, but this feature does not save each chapter from being in effect, a separate essay. The reader must accumulate in

his head the elaborate and elegant arguments and conclusions which Dr. Hartshorne's detailed logical analysis and brilliant discussions provide. The burden which the reader must carry in his head is suddenly lifted in the last chapter when it is revealed that the inductions lead to a conclusion agreeable with Hettner's deductions of the nature of geography. Hettner's classification of geography with astronomy and geophysics as a chorological science differentiated from the chrological sciences, history, prehistory, paleontology, etc., and the systematic sciences, botany, chemistry, etc, provides a framework into which Dr. Hartshorne's inductions fit, complete with the anthropocentric nature that he shows is a distinctive attribute of geography.

In the last chapter the toiling reader reaches the 'moment of truth' when the author, referring to Hettner's hypothesis, says, "Does the hypothesis presented in this concept explain particular characteristics of geography that were empirically determined ? To demonstrate this one needs only to reverse the order of discussion of this paper". Here is the secret of making the understanding of *Perspective on the Nature of Geography* easier: read the last chapter first.

The inductive approach used by Dr. Hartshorne is undoubtedly a monumental exercise in scholarly integrity, but the difficulties it creates in understanding the book as a whole will undoubtedly discourage many readers. To the degree that readers are discouraged *Perspective on* laudable purpose. The book would be more *the Nature or Geography* will fail in its very understandable on first reading were the inductive work preceded by a hypothesis, such as Hettner's, if not on the nature of geography, at least on the nature of science. Although such a procedure would compromise the purity of the empirical approach, it would not in any serious way affect the validity of the inductions, and would advantageously provide a framework for the progression of thought.

Space does not permit a chapter by chapter review. To a great extent each chapter gives clear answers to the questions 'how much should geography attempt ?' and 'by what methodological techniques should the attempts by made ?'. For example, Chapter V, "What is the Measure of Significance in Geography ?" provides authoritative judgment on how far geography should extend itself into other scientific fields, and will provide an orientation to those who overwhelmed by the implications of the 'wholistic' approach, are asking themselves 'Should I be a meteorologist, a botanist, a geologist, a historian ?'. Although he is careful to respect the personal judment of individual workers, Dr. Hartshorne does indicate that in specialization, obligations to the overall field of geography should not be forgotten. His opinion on the place of genetic geomorphology, expressed in Chapter V, "Time and Genesis in Geography", should be of interest to many Canadian geographers. In brief, he advocates that genetic geomorphology should be concerned only with the proximate genesis of landforms. "Whether required, as in the case of landforms of recent change, or whether it is an aid in comprehending the present configuration, at most geography is concerned only with the development of the relatively recent past — "proximate genesis". In Chapter IX, 'Is Geography Divided between "Systematic" and "Regional" Geography', it is shown that between systematic and regional geography 'there is no dichotomy or dualism, but rather a gradational range along a continuum from those which analyse the most elementary complexes in areal variation over the world to those which analyse the most complex integrations in areal variation within small areas'.

Perspective on the Nature of Geography will undoubtedly have the best influences in impressing on those who call themselves geographers the intellectual obligations of their profession. It would be desirable that these obligations should be inculcated at the undergraduate level, but it is rather too much to expect that undergraduates should fully comprehend all that is in the book. University teachers will have to run interference. The ultimate results will be worth the effort.

Gerald FREMLIN

TOWARD A GEOGRAPHY OF PRICE: A STUDY IN GEO-ECONOMETRICS by W. Warntz. 117 pp. University of Pennsylvania Press, Philadelphia, 1959. $5.00.

Dr. Warntz is a leading exponent of macroscopic analyses of patterns of geographical distributions, *Toward a Geography of Price* being an illustration of the macroscopic viewpiont. Readers of *The Canadian Geographer* (See No. 6, p. 39-49) may be familiar with a different application of the general approach through Warntz's article on the Newfoundland referendum in confederation with Canada in 1948. Dr. Warntz has been able to bring a breath of knowledge and varied experience to bear upon his particular problem. He is: a Research Associate at the American Geographical Society; on the faculty of the Wharton School of Finance and Commerce of the University of Pennsylvania; and closely associated in research with Dr. John Q. Stewart (Professor of Astronomical Physics, Princeton University), a prolific and competent writer on "social physics." This cross-ertilization has produced a book which is geographic in viewpoint, yet unique in its approach to the concept of the price of agricultural commodities, with which the book deals.

The objective of the book is the analysis of "the geographical variation of farm prices of certain agricultural commodities in terms of basic physical dimensions such as time, distance, and mass or size of given populations, whether or not those populations be comprised of human beings, bushels of wheat, or pounds of shorn wool." The reader who is familiar with the theoretical background of "social physics" or "potential studies" and multiple regression analysis will find the core of the book contained in

the commodity analyses and summary of results in chapters 3 and 4. The reader who is unfamiliar with these subjects will find an adequate introduction in chapters 1 and 2.

The distinctive approach employed in the book is the spatial concept of potential, where "populations" (the term being used in the statistical sense and not restricted to people) exert an influence varying with their size and diminishing with their distance. The total population potential at a given point is a summation of all potentials at that point. Several terms employed in the text need brief explanations: commodity farm price per unit (X_1) refers to the areal or spatial distribution of farm prices of various agricultural commodities in the United States; gross economic population potential (X_2) is a potential of population, weighted by income, and considering numbers of people and their locations; product supply space potential (X_3) and product supply time potential (X_4) refer to commodity (e.g. wheat) potential based upon production in space and time. Maps of the United States are given for the period 1940 to 1949 showing the annual gross economic population potential, annual wheat supply space potential, annual potato supply space potential, and annual onion space supply potential. Graphs show the supply time potentials, for the same period, for wheat, potato, onion and strawberry.

Regression analysis, with appropriate significance tests, has been used to test the theory "that the variation from place to place in the intensity of the demand for and the supply of that commodity." Warntz postulates, statistically, tests, and shows that there is a direct relationship between X_1 (see above) and X_2 and an inverse relationship with X_3 and X_4. Results of the regression studies are presented with statistical data on coefficients of multiple correlation, levels of significance, etc., so that the reader may appraise for himself the validity of the conclusions.

The potential ideas introduced and elaborated by Warntz may well appeal most to those geographers who are thoroughly familiar with interpreting and thinking of isopleth maps in a three-dimensional form. For others, the concept of potential may appear abstract, artificial or even unnecessary. For those interested in spatial problems, it cannot be ignored. The writer hopes that Warntz will follow *Toward a Geography of Price* with a more definitive volume, such as a "Geography of Price" in which the problem and the possibilities of potential studies will be explored in greater detail. Warntz has, however, made an excellent beginning.

J. Ross Mackay

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